1.2A, 30V Step Down DC/DC converter

NO.EA-269-120118

OUTLINE

The R1245x series are CMOS-based Step-down DC/DC converter with internal N-channel high side Tr. The ON resistance of the built-in high-side transistor is 0.35Ω and the R1245 can provide the maximum 1.2A output current. Each of the ICs consists of an oscillator, a PWM control circuit, a voltage reference unit, an error amplifier, a phase compensation circuit, a slope compensation circuit, a soft-start circuit, protection circuits, an internal voltage regulator, and a switch for bootstrap circuit. The ICs can make up a step-down DC/DC converter with an inductor, resistors, a diode, and capacitors.

The R1245x series are current mode operating type DC/DC converters without an external current sense resistor, and realizes fast response and high efficiency. As an output capacitor, a ceramic type capacitor can be used with the R1245X series. The options of the internal oscillator frequency are preset at 330kHz for version A and B, 500kHz for version C and D, 1000kHz for version E and F, 2400kHz for version G and H.

As for protection, an Lx peak current limit circuit cycle by cycle, a thermal shutdown function and an under voltage lockout (UVLO) function are built in. Furthermore, there are two types for short protection, for A/C/E/G version, a latch protection function which makes the output latch off if the output voltage keeps lower than the set output voltage for a certain time after detecting current limit is built in, for B/D/F/H version, a fold-back protection function which changes the oscillator frequency slower after detecting short circuit or equivalent.

As for the packages of the R1245 series, HSOP-8E, DFN(PLP)2020-8, SOT23-6W are available.

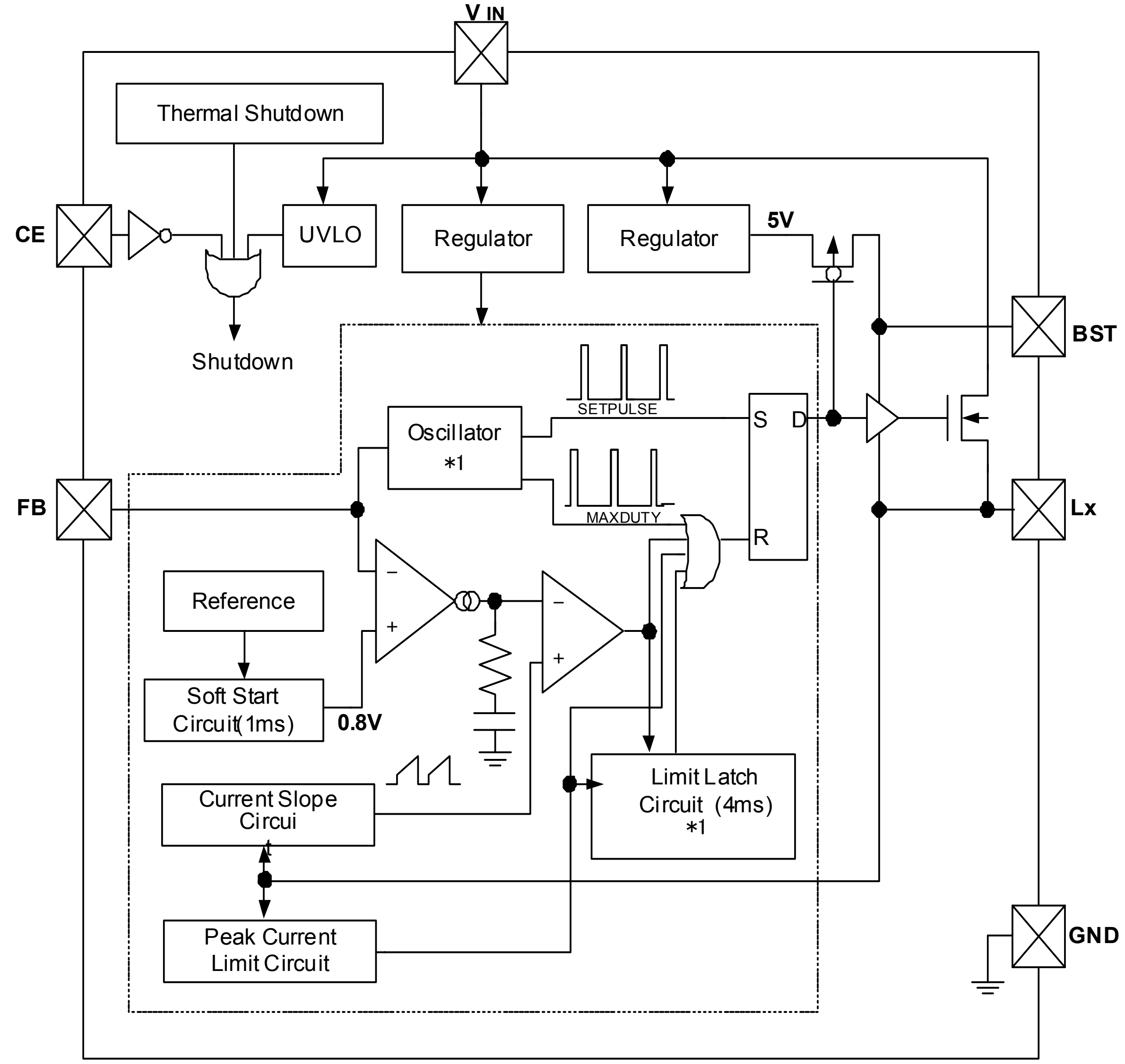
FEATURES

- Operating Voltage ········· 4.5V~30V
- Internal N-channel MOSFET Driver ········· R_{ON}=0.35Ω Typ.
- Adjustable output voltage with external resistor ········· 0.8V or more
- Feedback voltage and tolerance ········· 0.8V±1.0%
- Peak current limit ········· Typ. 2.0A
- UVLO function released voltage ········· Typ. 4.0V
- Operating frequency ········· 330kHz (A/B version), 500kHz (C/D version), 1000kHz (E/F version), 2400kHz (G/H version)
- Fold-back protected frequency ········· 170kHz (B/D version), 250kHz (F version), 400kHz (H version)
- Latch protection delay time ········· Typ. 4ms for A/C/E/G version
- Ceramic capacitors recommended for input and output.
- Stand-by current ········· Typ. 0μA
- Packages ········· SOT-23-6W, DFN(PLP)2020-8, HSOP-8E

APPLICATIONS

- Power source for digital home appliance such as digital TV, DVD players.
- Power source for 5V PSU or 2-cell or more Li-ion battery powered communication equipment, cameras, video instruments such as VCRs, camcorders.
- Power source for high voltage battery-powered equipment.
- Power source for office equipment such as printers and fax machines.

BLOCK DIAGRAMS



*1

Version	Oscillator frequency	Short protection type
A	330kHz	Latch
B	330kHz	Fold-back
C	500kHz	Latch
D	500kHz	Fold-back
E	1000kHz	Latch
F	1000kHz	Fold-back
G	2400kHz	Latch
H	2400kHz	Fold-back

SELECTION GUIDE

In the R1245x Series, the package, type of short protection (Latch or Fold back), and the oscillator frequency can be selected with the user's request.

Product code	Package	Quantity per reel	Pb free	Halogen free
R1245S003∗-E2-FE	HSOP-8E	1,000	Yes	Yes
R1245K003∗-TR	DFN(PLP)2020-8	5,000	Yes	Yes
R1245N001∗-TR-FE	SOT-23-6W	3,000	Yes	Yes

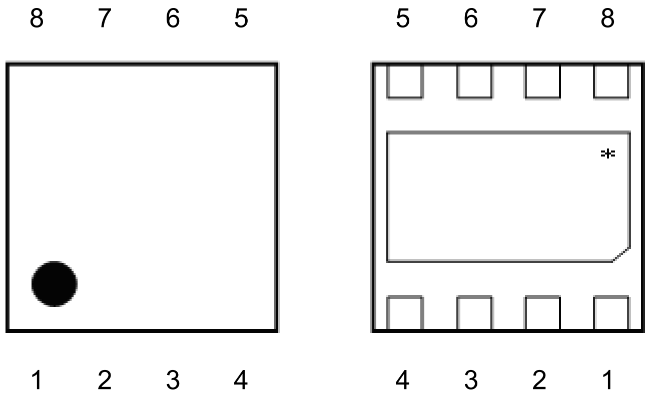
∗: Designation of the oscillator frequency and the protection function option.

Symbol	Oscillator frequency	Latch protection	Fold back protection
A	330kHz	✓	
B	330kHz		✓
C	500kHz	✓	
D	500kHz		✓
E	1000kHz	✓	
F	1000kHz		✓
G	2400kHz	✓	
H	2400kHz		✓

PIN CONFIGURATION

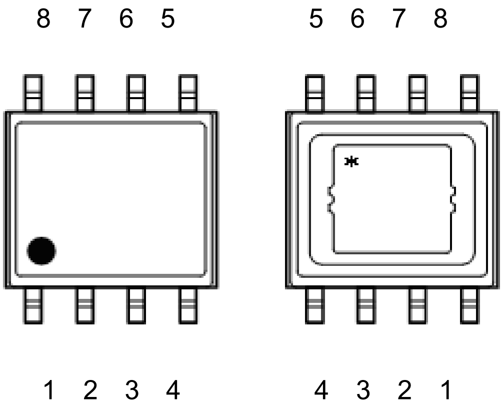
• **DFN(PLP)2020-8**

Top View **Bottom View**



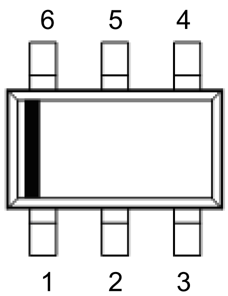
• **HSOP-8E**

Top View **Bottom View**



• **SOT-23-6W**

Top View



***Connect the backside heat radiation tub to GND or same as GND level (recommendation). The tub is connected to the GND pin.**

PIN DESCRIPTION

● **R1245S(HSOP-8E)**

Pin No.	Symbol	Description
1	L_X	L_X Switching Pin
2	V_{IN}	Power Supply Pin
3	CE	Chip Enable Pin (Active with "H")
4	TEST	TEST pin (must be open for user side.)
5	GND	Ground Pin
6	FB	Feedback Pin
7	NC	No connection
8	BST	Bootstrap Pin

*Connect the backside heat radiation tub to GND or same as GND level (recommendation). The tub is connected to the GND pin.

- **R1245K (DFN(PLP)2020-8)**

Pin No.	Symbol	Description
1	L_X	L_X Switching Pin
2	V_{IN}	Power Supply Pin
3	V_{IN}	Power Supply Pin
4	CE	Chip Enable Pin (Active with "H")
5	GND	Ground Pin
6	FB	Feedback Pin
7	TEST	Test Pin (must be open for user side.)
8	BST	Bootstrap Pin

*Connect the backside heat radiation tub to GND or same as GND level (recommendation). The tub is connected to the GND pin.

- **R1245N (SOT23-6W)**

Pin No.	Symbol	Description
1	BST	Bootstrap Pin
2	GND	Ground Pin
3	FB	Feedback Pin
4	CE	Chip Enable Pin (Active with "H")
5	V_{IN}	Power Supply Pin
6	L_X	L_X Switching Pin

ABSOLUTE MAXMUM RATINGS

(GND=0V)

Symbol	Item		Rating		Unit
V_{IN}	Input Voltage		-0.3 to 32.0		V
V_{BST}	BST Pin Voltage		V_{LX}-0.3 to V_{LX}+6.0		V
V_{LX}	L_X Pin Voltage		-0.3 to V_{IN}+0.3		V
V_{CE}	CE Pin Input Voltage		-0.3 to V_{IN}+0.3		V
V_{CE}	CE Pin input Voltage		-0.3 to V_{IN}+0.3		V
V_{FB}	Feedback Pin Voltage		-0.3 to 6.0		V
P_D	Power Dissipation	HSOP-8E	Standard Land Pattern*	2900	mW
		DFN(PLP)2020-8	Standard Land Pattern*	880	
		SOT-23-6W	Standard Land Pattern*	430	
Ta	Operating Temperature Range		-40 to 105		°C
Tstg	Storage Temperature Range		-55 to 125		°C

*For Power Dissipation, refer to the PACKAGE INFORMATION on the web site.

ABSOLUTE MAXIMUM RATINGS
Electronic and mechanical stress momentarily exceeded absolute maximum ratings may cause the permanent damages and may degrade the lifetime and safety for both device and system using the device in the field. The functional operation at or over these absolute maximum ratings is not assured.

ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, V_{IN}= 12V, Ta=25ºC)

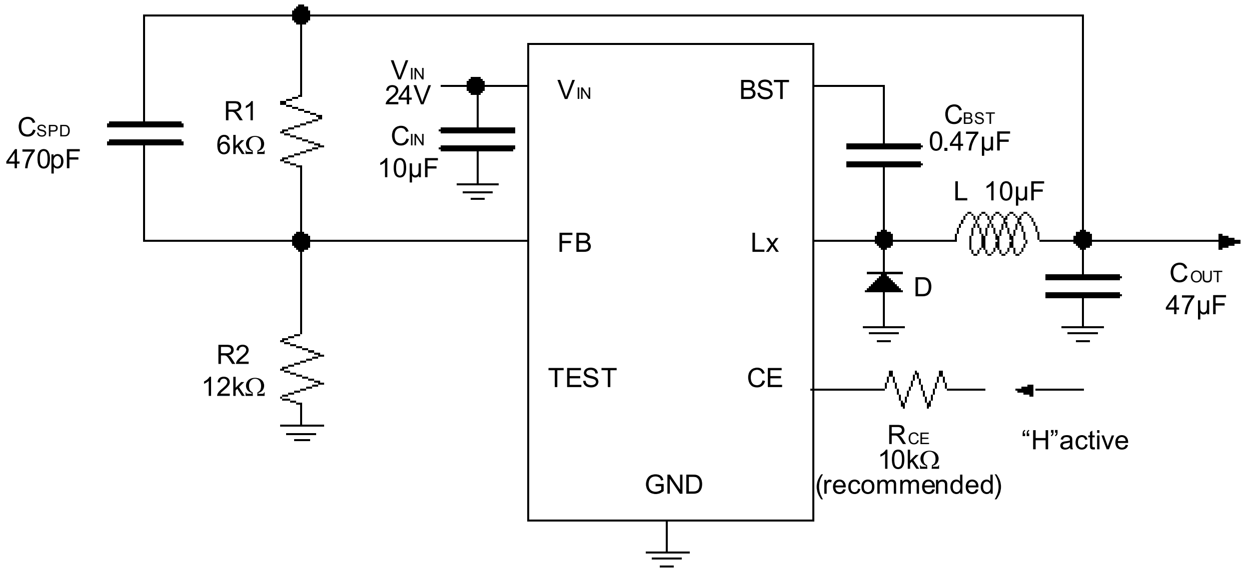
Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{IN}	Operating Input Voltage		4.5		30	V
I_{IN}	V_{IN} Consumption Current	V_{IN}=30V, V_{FB}=1.0V		0.5	1.0	mA
V_{UVLO1}	UVLO Detect Voltage	Specified V_{IN} falling edge	3.6	V_{UVLO2} -0.2	V_{UVLO2} -0.1	V
V_{UVLO2}	UVLO Released Voltage	Specified rising edge	3.8	4.0	4.2	V
V_{FB}	V_{FB} Voltage Tolerance		0.792	0.800	0.808	V
$\Delta V_{FB}/\Delta T$	V_{FB} Voltage Temperature Coefficient	-40ºC ≤ Ta ≤ 105ºC		±100		ppm/ºC
f_{OSC}	Oscillator Frequency	Version A/B	300	330	360	kHz
		Version C/D	450	500	550	
		Version E/F	900	1000	1100	
		Version G/H	2200	2400	2600	
f_{FLB}	Fold back Frequency	V_{FB}<0.56V, Version B/D		170		kHz
		V_{FB}<0.56V, Version F		250		
		V_{FB}<0.56V, Version H		400		
Maxduty	Oscillator Maximum. Duty Cycle	Version A/B/C/D	92			%
		Version E/F	88			
		Version G/H	76			
t_{SS}	Soft-start Time	V_{FB}=0.72V		1		ms
t_{DLY}	Delay Time for Latch Protection	Version A/C/E/G		4		ms
R_{LXH}	Lx High Side Switch ON Resistance	V_{BST}-V_{LX}=4.5V		0.35		Ω
I_{LXHOFF}	Lx High Side Switch Leakage Current	V_{IN}=30V, V_{CE}=0V		0	5	µA
I_{LIMLXH}	Lx High Side Switch Limited Current	V_{BST}-V_{LX}=4.5V	1.5	2.0	2.7	A
V_{CEL}	CE “L” Input Voltage	V_{IN}=30V			0.3	V
V_{CEH}	CE “H” Input Voltage	V_{IN}=30V	1.6			V
I_{FB}	V_{FB} Input Current	V_{IN}=30.0V, V_{FB}=1.0V	-1.0		1.0	µA
I_{CEL}	CE “L” Input Current	V_{IN}=30V, V_{CE}=0V	-1.0		1.0	µA
I_{CEH}	CE “H” Input Current	V_{IN}=30V, V_{CE}=30V	-1.0		1.0	µA
T_{TSD}	Thermal Shutdown Detect Temperature	Hysteresis 30ºC		160		ºC
$I_{standby}$	Standby Current	V_{IN}=30V		0	5	µA

RECOMMENDED OPERATING CONDITIONS (ELECTRICAL CHARACTERISTICS)

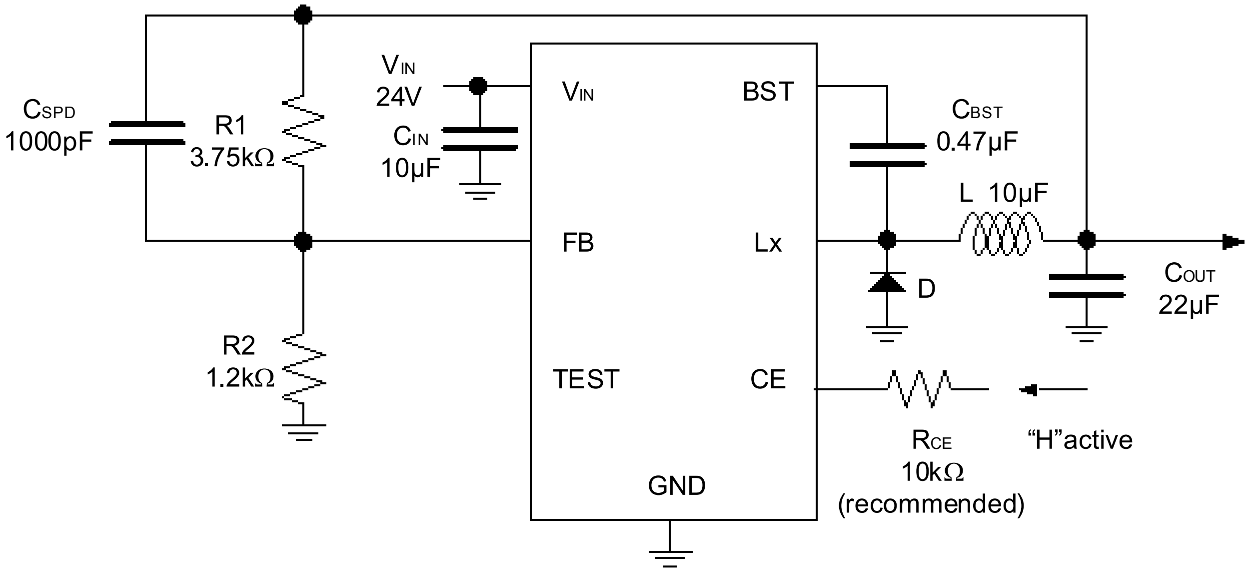
All of electronic equipment should be designed that the mounted semiconductor devices operate within the recommended operating conditions. The semiconductor devices cannot operate normally over the recommended operating conditions, even if when they are used over such conditions by momentary electronic noise or surge. And the semiconductor devices may receive serious damage when they continue to operate over the recommended operating conditions.

TYPICAL APPLICATION

R1245x00xA/B 330kHz V_{OUT}=1.2V V_{IN}=24V

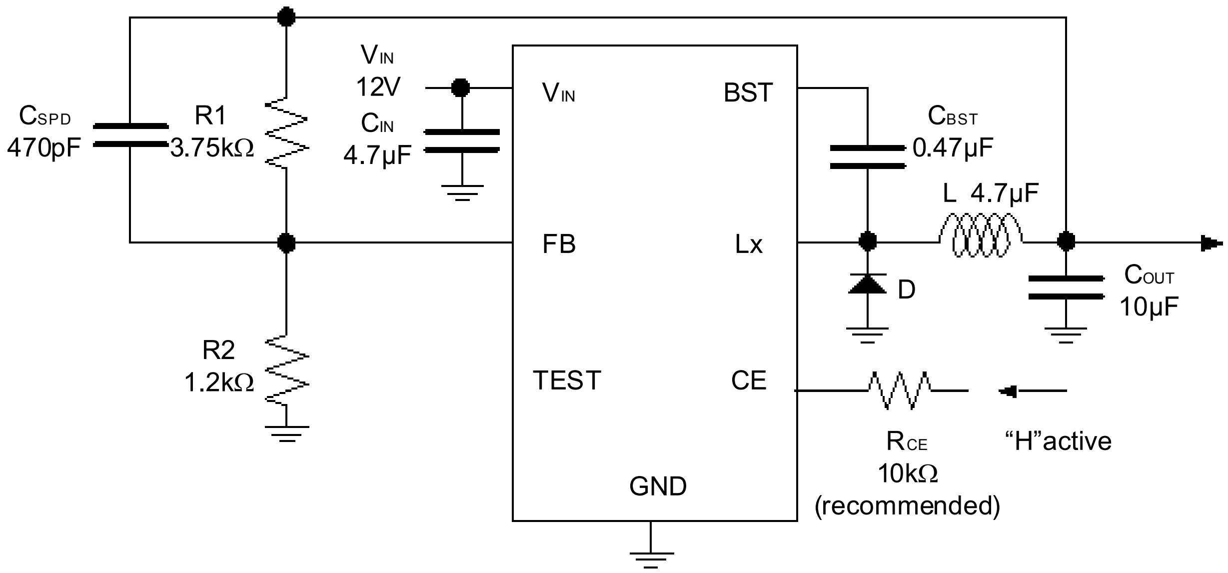


R1245x00xC/D 500kHz V_{OUT}=3.3V V_{IN}=24V

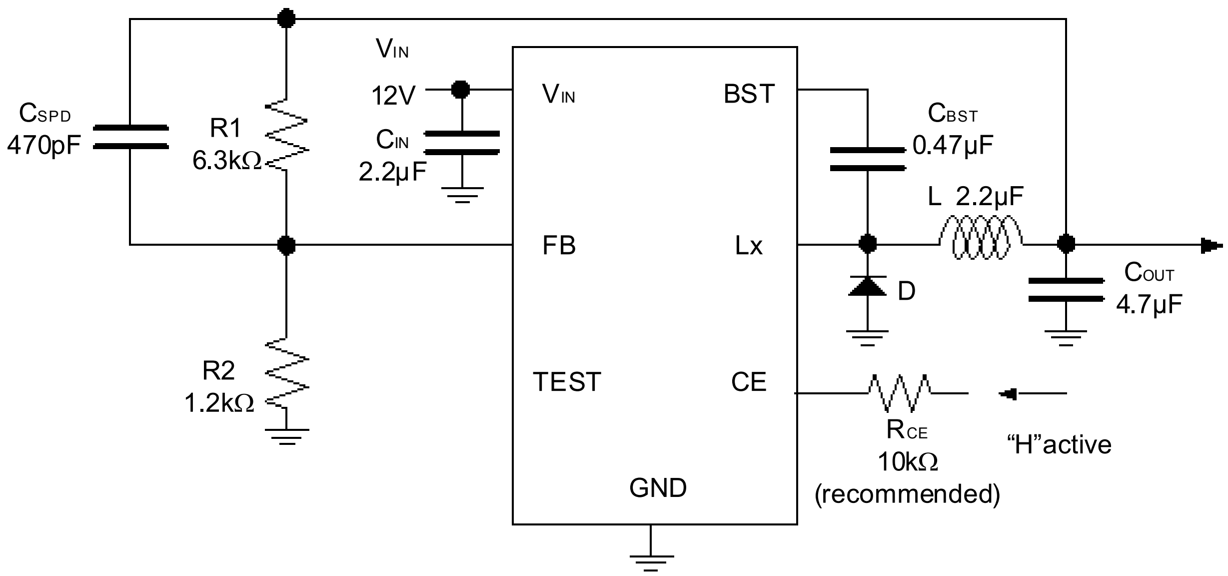


*TEST pin must be open.

R1245x00xE/F 1000kHz V_{OUT}=3.3V V_{IN}=12V



R1245x00xG/H 2400kHz V_{OUT}=5.0V V_{IN}=12V



*TEST pin must be open.

TECHNICAL NOTES

*External components must be connected as close as possible to the ICs and make wiring as short as possible. Especially, the capacitor connected in between V_{IN} pin and GND pin must be wiring the shortest. If their impedance is high, internal voltage of the IC may shift by the switching current, and the operating may be unstable. Make the power supply and GND lines sufficient. In the wiring of the power supply, GND, L_X, V_{OUT} and the inductor, large current by switching may flow. To avoid the bad influence, the wiring between the resistance, "Rup" for setting the output voltage and loading, and the wiring between the inductor and loading must be separated.

*The ceramic capacitors have low ESR (Equivalent Series Resistance) and recommended for the ICs. The recommendation of C_{IN} capacitor between V_{IN} and GND is 10μF or more for A/B/C/D version, 4.7μF or more for E/F version, and 2.2μF or more for G/H version. Verify the bias dependence and the temperature characteristics

of the ceramic capacitors. Recommendation conditions are written based on the case which the recommendation parts are used with the R1245.

*The R1245 series are designed with the recommendation inductance value and ceramic capacitor value and phase compensation has been made. If the inductance value is large, due to the lack of current sensing amount of the current mode, unstable operation may result. On the contrary, if the inductance value is small, the current sensing amount may increase too much, low frequency oscillation may occur when the on duty ratio is beyond 50%. Not only that, if the inductance value is small, according to the increase of the load current, the peak current of the switching may increase, as a result, the current may reach the current limit value and the current limit may work.

*As for the diode, use the Schottky diode with small capacitance between terminals. The reference characteristic of the capacitance between terminals is around 100pF or less at 10V. If the capacitance between terminals is large, excess switching current may flow and the operation of the IC may be unstable. If the capacitance between terminals of the Scottky diode is beyond 100pF at 10V or unknown, verify the load regulation, line regulation, and the load transient response.

*Output voltage can be set by adjustment of the values of R1 and R2. The equation of setting the output voltage is $V_{OUT}=V_{FB} \times (R1+R2)/R2$. If the values of R1 and R2 are large, the impedance of FB pin increases, and pickup the noise may result. The recommendation value range of R2 is approximately between 1.0kΩ to 16kΩ. If the operation may be unstable, reduce the impedance of FB pin.

*For the CE pin, as an ESD protection element, a diode to V_{IN} pin is formed internal of the IC. If CE pin voltage may become higher than V_{IN} pin voltage, to prevent flowing large current from CE pin to V_{IN} pin, connect 10kΩ or more resistor between CE and V_{IN} pin.

*Connect the backside heat radiation tub of the DFN(PLP)2020-9/HSOP-8E to the GND. As for multi-layered boards, to make better power dissipation, putting some thermal vias on the thermal pad in the land pattern and radiation of the heat to another layer is effective.

*After the soft-start operation, the latch function is enabled for version A/C/E/G. The latch protection starts the internal counter when the internal current limit protection circuit detects the current limit. When the internal counter counts up to the latch timer limit, typically 4ms, the output is latched off. To reset the latch function, make the CE pin “L”, or make V_{IN} pin voltage lower than UVLO detector threshold. Then in the case that the output voltage or FB voltage becomes setting voltage within the latch timer preset time, counter is initialized. If the slew rate of the power supply is too slow and after the soft-start time, the output voltage does not reach the set output voltage even if the latch timer preset time is over, the latch function may work unexpectedly.

*After the soft-start operation, fold back protection function is enabled for version B/D/F/H. The fold back function will limit the oscillator frequency if the FB pin voltage becomes lower than typically 0.56V. For B/D version, the oscillator frequency will be reduced typically into 170kHz, for F version, into 250kHz, for H version, into 400kHz. If the slew rate of the power supply is too slow, and even after the soft-start time, the output voltage is still less than 70% of the set output voltage, or FB pin voltage is less than typically 0.56V, then this function may work unexpectedly.

The performance of power circuit using this IC largely depends on external components. Selection of external components is very important, especially, do not exceed each rating value (voltage/current/power).

Recommended values for each output voltage

R1245x00xA/B: 330kHz

V_{OUT} (V)	0.8 to 1.2	1.2 to 2.5	2.5 to 5.0	5.0 ≤
R1(R_{UP}) (kΩ)	=(V_{OUT} / 0.8-1) × R2			
R2(R_{BOT}) (kΩ)	16	12	1.20	1.20
C_{SPD} (pF)	open	470	2200	1000
C_{OUT} (μF)	47	47	22	22
L(μH)	4.7	10	15	33

R1245x00xC/D : 500kHz

V_{OUT} (V)	0.8 to 1.2	1.2 to 1.5	1.5 to 2.0	2.0 to 5.0	5.0 to 12.0	12.0 ≤
R1(R_{UP}) (kΩ)	=(V_{OUT} / 0.8-1) × R2					
R2(R_{BOT}) (kΩ)	16	16	16	1.2	1.2	1.2
C_{SPD} (pF)	open	100	100	1000	1000	470
C_{OUT} (μF)	100	100	22	22	22	22
L(μH)	4.7	4.7	10	10	15	15

R1245x00xE/F : 1000kHz

V_{OUT} (V)	0.8 to 1.0	1.0 to 1.2	1.2 to 1.5	1.5 to 2.5	2.5 to 5.0	5.0 ≤
R1(R_{UP}) (kΩ)	=(V_{OUT} / 0.8-1) × R2					
R2(R_{BOT}) (kΩ)	16	16	16	16	1.2	1.2
C_{SPD} (pF)	open	100	100	100	470	470
C_{OUT} (μF)	100	100	47	22	10	10
L(μH)	2.2	2.2	2.2	2.2	4.7	10

R1245x00xG/H : 2400kHz

V_{OUT} (V)	1.2 to 1.8	1.8 to 2.5	2.5 to 5.0	5.0 ≤
R1(R_{UP}) (kΩ)	=(V_{OUT} / 0.8-1) × R2			
R2(R_{BOT}) (kΩ)	16	12	1.2	1.2
C_{SPD} (pF)	100	100	470	470
C_{OUT} (μF)	10	10	4.7	4.7
L(μH)	1.0	1.5	2.2	4.7

*Divider resisters values and possible setting range of input /output

V_{OUT} [V]	R1(R_{UP}) [kΩ]	R2(R_{BOT}) [kΩ]	Input Voltage range [V]			
			Ver.AB	Ver.CD	Ver.EF	Ver.GH
0.8	0	open	4.5 to 20	4.5 to 13.5	4.5 to 7	-
	0	16				
1	4	16	4.5 to 25.5	4.5 to 17	4.5 to 8.5	-
1.2	8	16	4.5 to 30	4.5 to 20	4.5 to 10	-
	6	12				
1.5	10.5	12	4.5 to 30	4.5 to 25	4.5 to 12.5	4.5 to 5.5
	14	16				
1.8	20	16	4.5 to 30	4.5 to 30	4.5 to 15	4.5 to 6.5
	15	12				
2	24	16	4.5 to 30	4.5 to 30	4.5 to 17	4.5 to 7
	1.8	1.2				
2.5	34	16	4.5 to 30	4.5 to 30	4.5 to 21	4.5 to 9
	25.5	12				
	2.55	1.2				
3.3	3.75	1.2	4.5 to 30	4.5 to 30	4.5 to 27.5	4.5 to 12
5	6.3	1.2	4.5 to 30	5.5 to 30	6 to 30	7 to 12
6	7.8	1.2	6.5 to 30	6.5 to 30	7 to 30	12 to 23
9	12.3	1.2	10 to 30	10 to 30	11 to 30	12 to 30
12	16.8	1.2	13.0 to 30	13 to 30	14 to 30	16 to 30
15	21.3	1.2	16.5 to 30	13 to 30	17 to 30	20 to 30
24	34.8	1.2	26.5 to 30	26.5 to 30	27.5 to 30	30

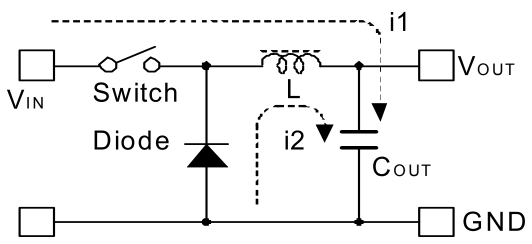
Recommended external Components examples (Considering all the range)

Symbol	Characteristics	Value	Parts Name	MFR
C_{IN}	50V/X5R	10μF	UMK325BJ106MM-T	TAIYO YUDEN
	50V/X7R	4.7μF	GRM31CR71H475KA12L	MURATA
	50V/X7R	2.2μF	GRM31CR71H225KA88L	MURATA
C_{OUT}	50V/X5R	10μF	UMK325BJ106MM-T	TAIYO YUDEN
	50V/X7R	10μF	KTS500B106M55N0T00	Nippon Chemi-Con
	25V/X7R	10μF	GRM31CR71E106K	MURATA
	10V/X7R	22μF	GRM31CR71A226M	MURATA
	16V B	47μF	GRM32EB31C476KE15	MURATA
	10V/X7R	47μF	GRM32ER71A476KE15	MURATA
			NOTE: The value of C_{OUT} depends on the setting output voltage.	
C_{BST}	16V/X7R	0.47μF	EMK212B7474KD-T	TAIYO YUDEN
L	1.8A	10μH	SLF6045T-100M1R6-3PF	TDK
	1.65A	4.7μH	SLF7045T-4R7M2R0-PF	TDK
	1.7A	4.7μH	NR4018T-4R7M2R0-PF	TDK
	2.4A	4.7μH	NR6020T4R7M	TAIYO YUDEN
	1.9A	10μH	NR6028T100M	TAIYO YUDEN
	2.3A	15μH	NR6045T150M	TAIYO YUDEN
	1.9A	22μH	NR6045T220M	TAIYO YUDEN
	1.9A	33μH	NR8040T330M	TAIYO YUDEN
	1.7A	2.2μH	VLCF4020T-2R2N1R7	TDK
	1.65A	2.2μH	NR4012T2R2M	TAIYO YUDEN
	1.8A	1.5μH	NR3015T1R5N	TAIYO YUDEN
	1.8A	1.0μH	NR4010T1R0N	TAIYO YUDEN
D	30V/1.5A	0.42V	MA22D28	Panasonic
	30V/2.0A	0.37V	CMS06	TOSHIBA
	40V/2.0A	0.55V	CMS11	TOSHIBA
	40V/2.0A	0.43V	MA24D60	Panasonic
	15V/2.0A	0.32V	SBS010M	SANYO
R_{CE}	An UP DIODE is formed between the CE pin and the V_{IN} pin as an ESD protection element. If the CE pin may become higher than the voltage of the V_{IN} pin, connect the 10kohm resistance between the CE pin and V_{IN} pin, to prevent a large current from flowing into the V_{IN} pin from the CE pin.			

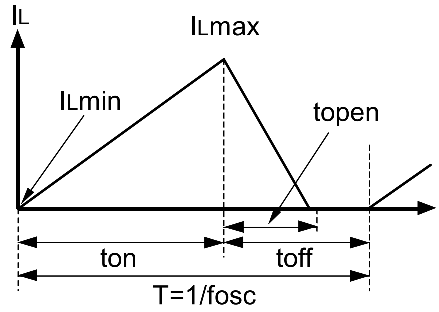
Operation of the Buck Converter and the Output Current

The DC/DC converter charges energy in the inductor when the switch turns on, and discharges the energy from the inductor when the switch turns off and controls with less energy loss, so that a lower output voltage than the input voltage is obtained. Refer to the following figures.

<Basic Circuit>



<Current through the inductor>



Step 1: The switch turns on and current IL (=i1) flows, and energy is charged into C_{OUT}. At this moment, IL increases from IL_{min} (=0) to reach IL_{max} in proportion to the on-time period (t_{on}) of the switch.

Step 2: When the switch turns off, the diode turns on in order to maintain IL at IL_{max}, and current IL (=i2) flows.

Step 3: IL (=i2) decreases gradually and reaches IL=IL_{min}=0 after a time period of topen, and the diode turns off. This case is called as discontinuous mode. If the output current becomes large, next switching cycle starts before I_L becomes 0 and the diode turns off. In this case, IL value increases from IL_{min} (>0), and this case is called continuous mode.

In the case of PWM control system, the output voltage is maintained by controlling the on-time period (t_{on}), with the oscillator frequency (f_{osc}) being maintained constant.

Output Current and Selection of External Components

The relation between the output current and external components is as follows:

When the switch of L_X turns on:

(Wherein, the peak to peak value of the ripple current is described as I_{RP}, the ON resistance of the switch is described as R_{ONH}, and the diode forward voltage as V_F, and the DC resistance of the inductor is described as R_L, and on time of the switch is described as ton)

$V_{IN} = V_{OUT} + (R_{ONH} + R_L) \times I_{OUT} + L \times I_{RP} / ton$ ·································· Equation 1

When the switch turns off (the diode turns on) as t_{off}:

$L \times I_{RP} / t_{off} = V_F + V_{OUT} + R_L \times I_{OUT}$ ·································· Equation 2

Put Equation 2 to Equation 1 and solve for ON duty of the switch, $t_{on} / (t_{off} + t_{on}) = D_{ON}$,

$D_{ON} = (V_{OUT} + V_F + R_L \times I_{OUT})/(V_{IN} + V_F - R_{ONH} \times I_{OUT})$ ·································· Equation 3

Ripple Current is as follows:

$I_{RP} = (V_{IN} - V_{OUT} - R_{ONH} \times I_{OUT} - R_L \times I_{OUT}) \times D_{ON} / f_{osc} / L$ ············ Equation 4

wherein, peak current that flows through L, and the peak current ILmax is as follows:

$ILmax = I_{OUT} + I_{RP} / 2$ ············ Equation 5

As for the valley current ILmin,

$ILmin = I_{OUT} - I_{RP} / 2$ ············ Equation 6

If ILmin<0, the step-down DC/DC converter operation becomes current discontinuous mode.
Therefore the current condition of the current discontinuous mode, the next formula is true.

$I_{OUT} < I_{RP} / 2$ ············ Equation 7

Consider ILmax and ILmin, conditions of input and output and select external components.

*The above explanation is based on the calculation in an ideal case in continuous mode.

Ripple Current and Lx current limit

The ripple current of the inductor may change according to the various reasons. In the R1245x series, as an Lx current limit, Lx peak current limit is used. Therefore the upper limit of the inductor current is fixed.
The peak current limit is not the average current of the inductor (output current). If the ripple current is large, peak current becomes also large. The characteristic is used for the fold back current limit of version B/D/F/H. In other words, the peak current limit is maintained and the switching frequency is reduced, as a result, the average current of the inductor is reduced. To release this condition, at 170kHz for version B/D, at 250kHz for version F, at 400kHz for version H must not be beyond the peak current limit. In the fig.1, the sequence of the Lx current limit function is described.

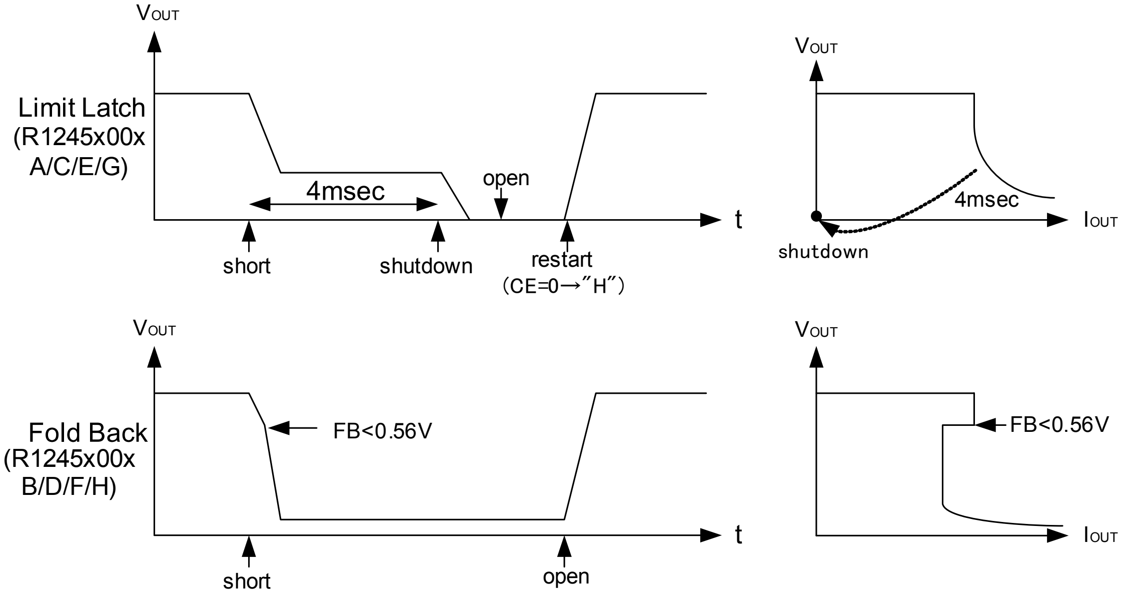


Fig.1 Lx Limit function sequence

Latch protection function for version A/C/E/G
The latch function works after detecting current limit and if the output voltage becomes low for a certain time, the output is latched off. Refer to the TECHNICAL NOTES.

Fold back protection function for version B/D/F/H
If FB voltage becomes lower than approximately 0.56V, the fold back protection function limits the oscillator frequency to typically 170kHz for version B/D, typically 250kHz fir version F, typically 400kHz for version H. By reducing frequency, the ripple current increases. The R1245x has the peak current limit function, therefore as in the equation 8, the Lx average current decreases by the increase of the ripple current.

$$I_{OUT} = ILmax + I_{RP} / 2 \qquad \text{Equation 8}$$

If FB voltage becomes less than 0.56V, the oscillator frequency is reduced. At heavy load, if the R1245x becomes into the fold back protection mode, the situation may not be released by increase the ripple current. In terms of other notes on this protection function, refer to the TECHNICAL NOTES.

MAXIMUM OUTPUT CURRENT

The output current of the R1245x is limit by the power dissipation P_D of the package and the maximum specification 1.2A. The loss of the IC includes the switching loss, and it is difficult to estimate. To estimate the maximum output, using the efficiency data is one method.
By using the efficiency data, the loss including the external components can be calculated with the equation, (100/efficiency(%)-1)x(V_{OUT}(V)xI_{OUT}(V)). From this equation, by reducing the loss of external components, the loss of the IC can be estimated. The main loss of the external components is composed by the rectifier diode

and DCR of the inductor. Supposed that the forward voltage of the diode is described as V_F, the loss of the diode can be described as follows:
$(V_{IN}(V)-R_{ON}(\Omega)xI_{OUT}(A)-V_{OUT}(V)-V_F(V)))/V_{IN}(V)xV_F(V)xI_{OUT}(A)$
The loss by the DCR of the inductor can be calculated by the formula $DCR(\Omega)xI_{OUT}^2(A)$.
Thus,
The loss of the IC = (100 / efficiency(%) -1) x (V_{OUT}(V) x I_{OUT}(A) - (V_{IN}(V) - R_{ON}(Ω) x I_{OUT}(A) - V_{OUT}(V) -V_F(V)) / V_{IN}(V) x V_F(V) xI_{OUT}(A) - DCR(Ω) x I_{OUT}^2(A)

The efficiency of the R1245 at Ta=25°C, V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=600mA is approximately 89.5% for version A/B(Oscillator frequency 330kHz). Supposed that the On resistance of the internal driver is 0.35Ω, the DCR of the inductor is 65mΩ, the V_F of the rectifier diode is 0.3V and applied to the formula above,
The loss of the IC = (100% / 89.5% - 1) x (3.3V x 0.6A) - (12V - 0.35Ω x 0.6A - 3.3V - 0.3V) / 12V x 0.3V x 0.6A - 0.065Ωx0.6^2A=47mW
The power dissipation P_D of the package is specified at Ta=25°C based on the Tjmax=125°C. Thus the thermal resistance of the package θja=(Tjmax(°C)-Ta(°C))/P_D(W), therefore the thermal resistance of the each available package is as follows:
HSOP-8E: (125°C-25°C)/2.9W=34.5°C/W
DFN(PLP)2020-8: (125°C-25°C)/0.88W=114°C/W
SOT-23-6W: (125°C-25°C)/0.43W=233°C/W
Due to the loss of the IC is 47mW for this example, therefore Tj increase of the each package is as follows:
HSOP-8E: 34.5°C/Wx47mW=1.6°C
DFN(PLP)2020-8: 114°C/Wx47mW=5.4°C
SOT-23-6W: 233°C/Wx47mW=11°C

For all the packages, even if the ambient temperature is at 105°C, Tj can be suppressed less than 125°C. By the increase of the temperature, on resistance and switching loss increases, therefore, temperature margin is not enough, measure the efficiency at the actual maximum temperature and recalculation is necessary.

At the same condition, if the preset frequency is 2400kHz, the efficiency will be down to approximately 81%. The result of the loss calculation is 310mW, therefore the Tj increase of each package is,

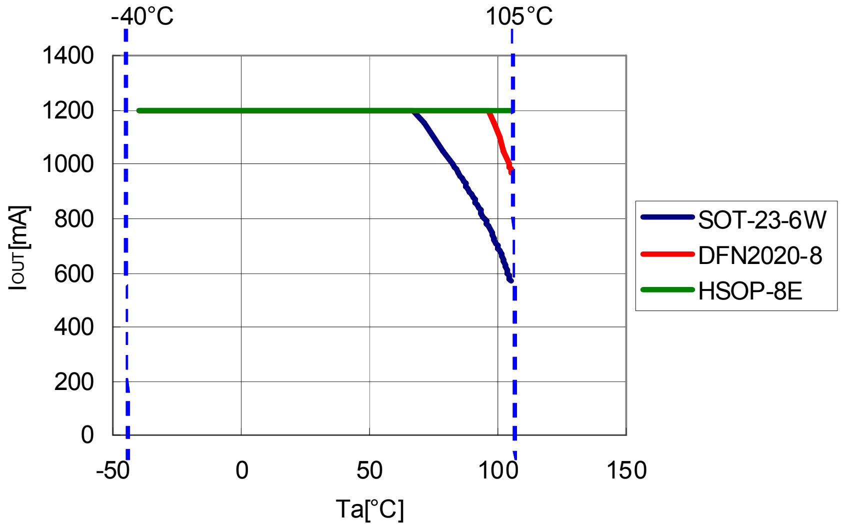
HSOP-8E: 34.5°C/Wx310mW=11°C
DFN(PLP)2020-8: 114°C/Wx310mW=35°C
SOT-23-6W: 233°C/Wx310mW=72°C

HSOP-8E can be used at the ambient temperature 105°C, DFN(PLP)2020-8 can be used at the ambient temperature up to 90°C, SOT-23-6W can be used at the ambient temperature up to 53°C. Note that the result is different by the frequency.

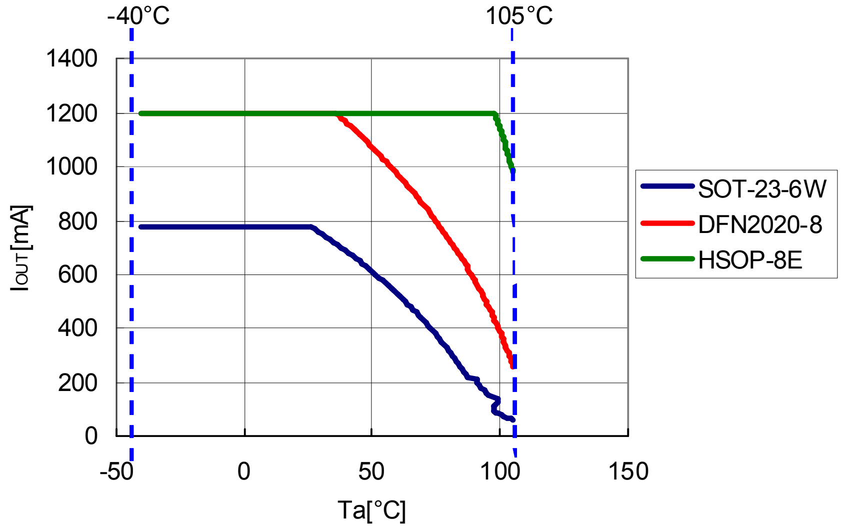
The next graphs are the output current and estimated ambient temperature limit.

Maximum output current

V_{IN}=12V , V_{OUT}=3.3V , fosc=330kHz

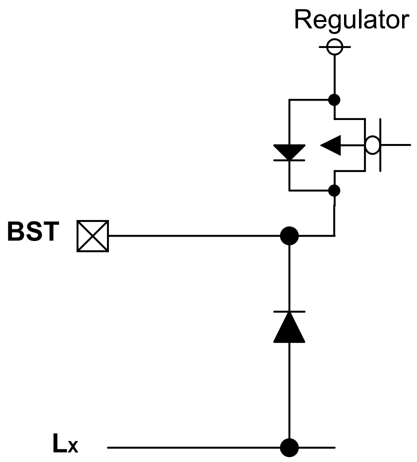


V_{IN}=12V , V_{OUT}=3.3V , fosc=2400kHz

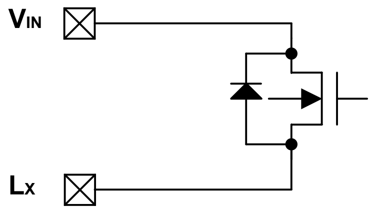


INTERNAL EQUIVALENT CIRCUIT FOR EACH PIN

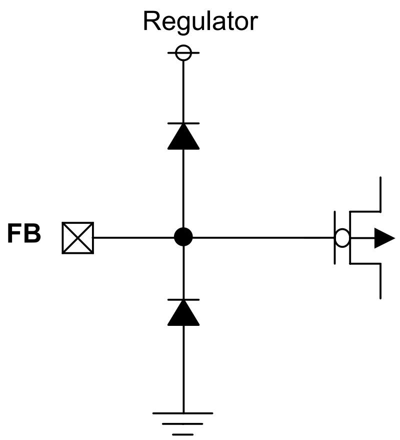
<BST pin>



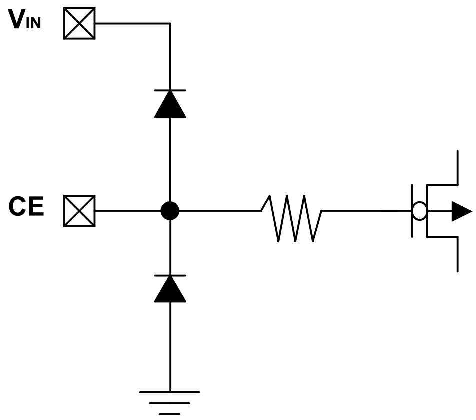
<Lx pin>



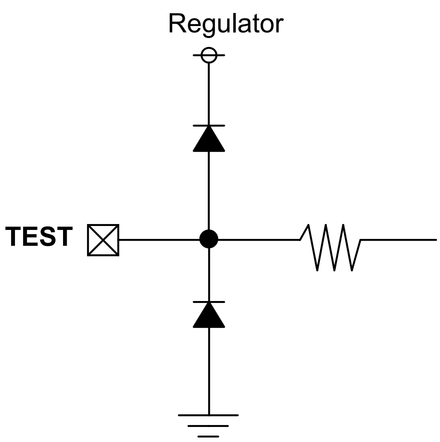
<FB pin>



<CE pin>



<TEST pin>

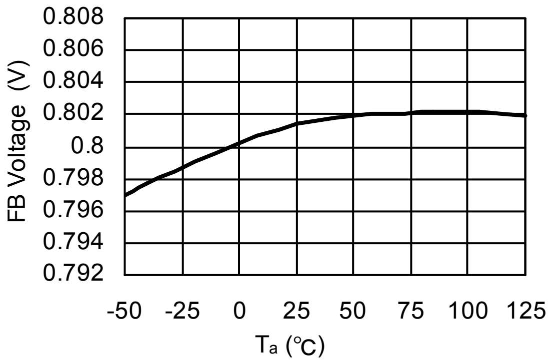


TYPICAL CHARACTERISTICS

1) FB voltage vs. Temperature

R1245x00xx

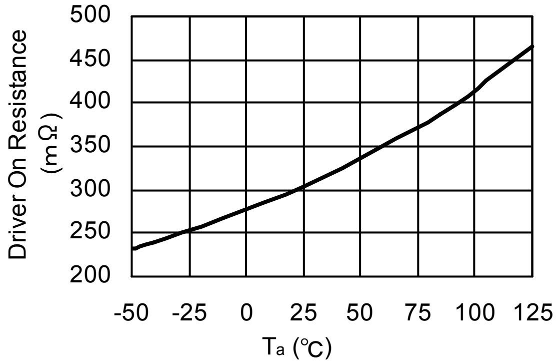
(V_{IN}=12V)



2)Driver On resistance vs. Temperature

R1245x00xx

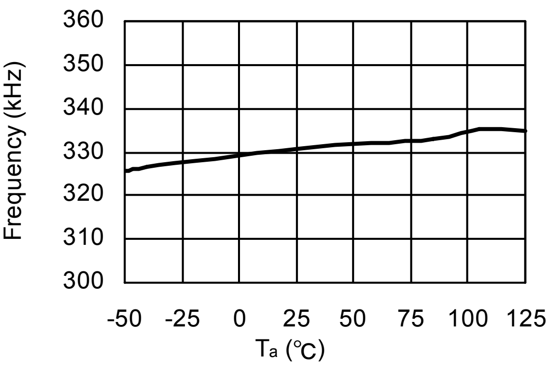
(V_{IN}=12V)



3) Oscillator frequency vs. Temperature

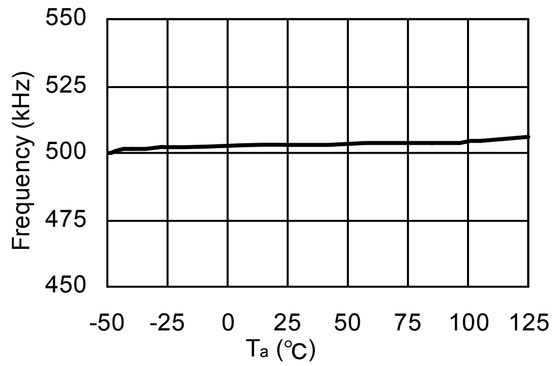
R1245x00xA/R1245x00xB

(V_{IN}=12V)



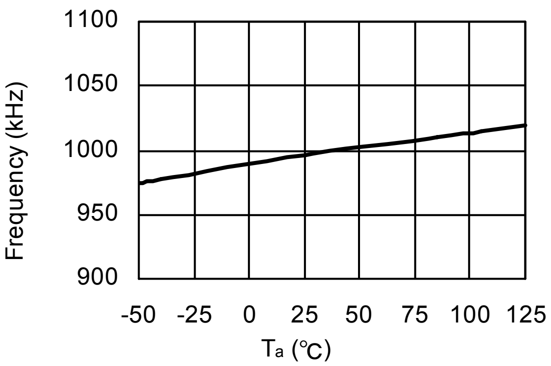
R1245x00xC/R1245x00xD

(V_{IN}=12V)



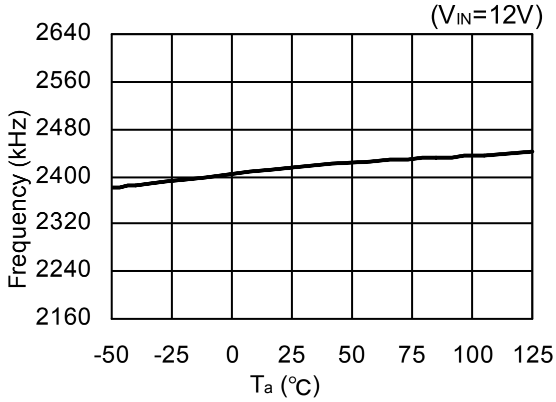
R1245x00xE/R1245x00xF

(V_{IN}=12V)



R1245x00xG/R1245x00xH

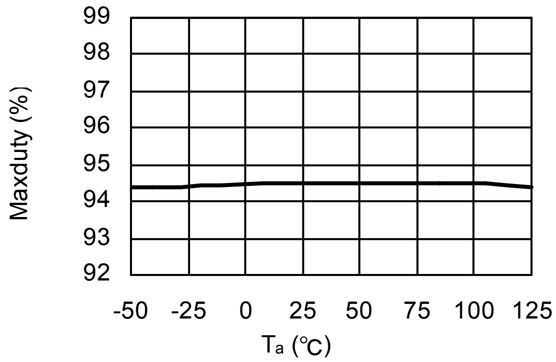
(V_{IN}=12V)



4) Maximum duty cycle vs. Temperature

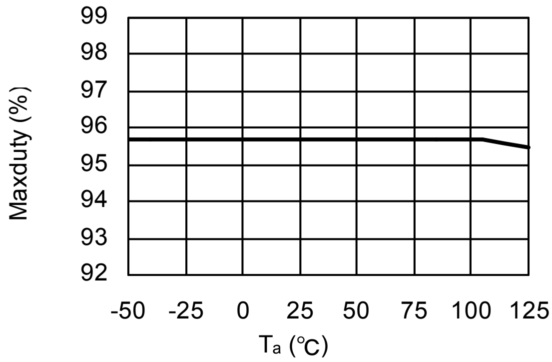
R1245x00xA/R1245x00xB

(V_{IN}=12V)



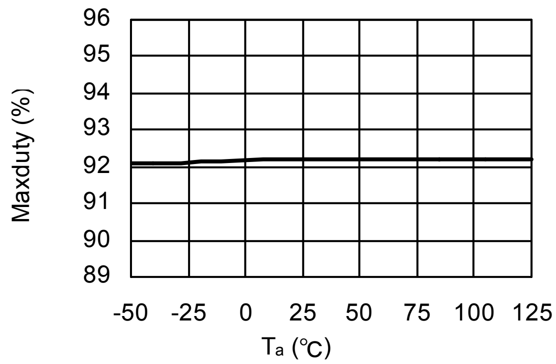
R1245x00xC/R1245x00xD

(V_{IN}=12V)



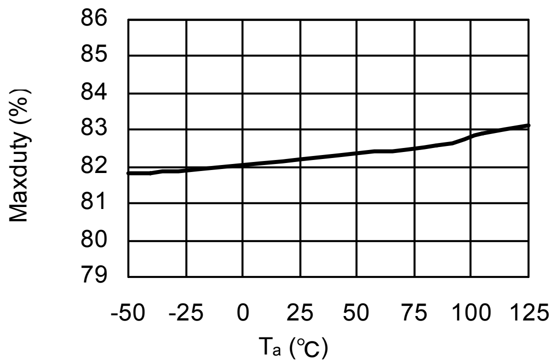
R1245x00xE/R1245x00xF

(V_{IN}=12V)



R1245x00xG/R1245x00xH

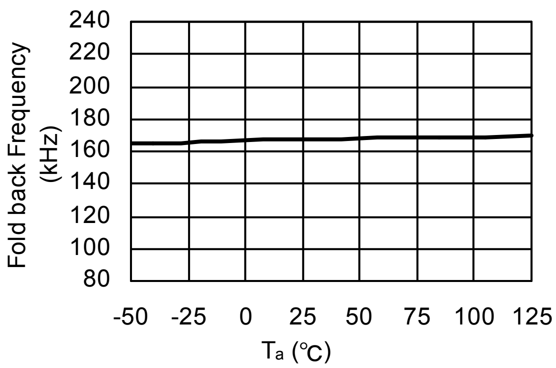
(V_{IN}=12V)



5) Fold back frequency vs. Temperature

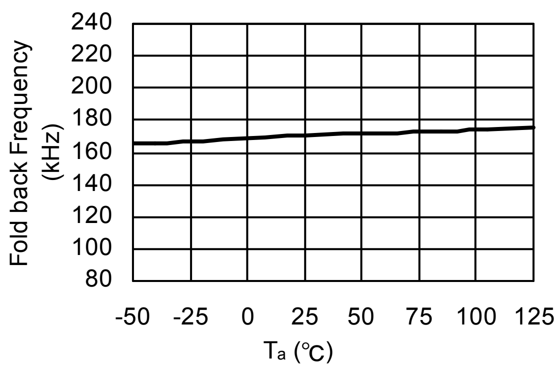
R1245x00xB

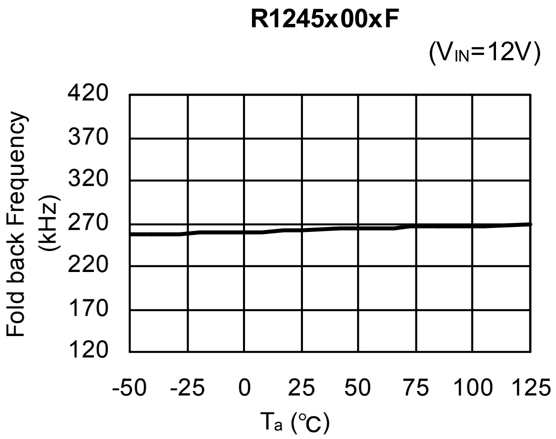
(V_{IN}=12V)

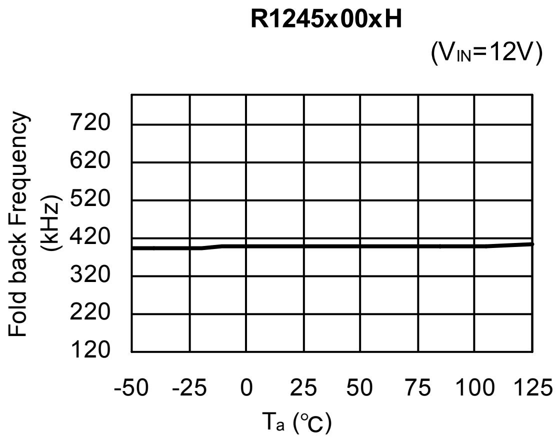


R1245x00xD

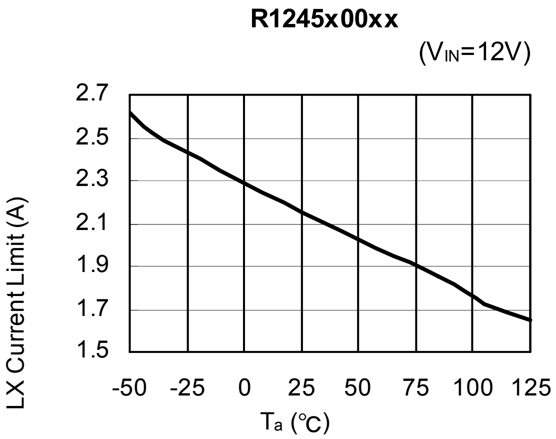
(V_{IN}=12V)



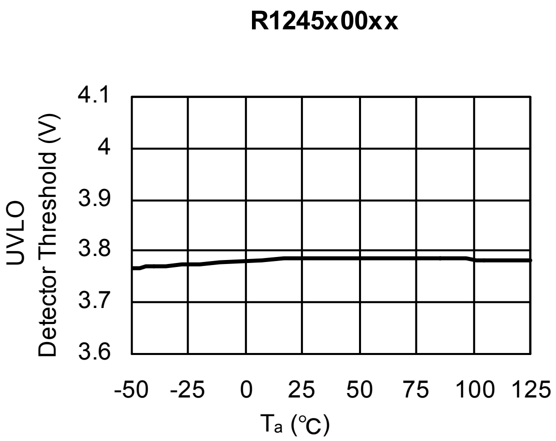




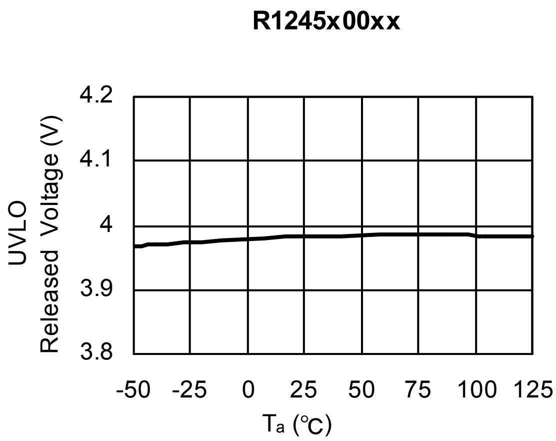
6) High side switch current limit vs. Temperature



7) UVLO detector threshold vs. Temperature



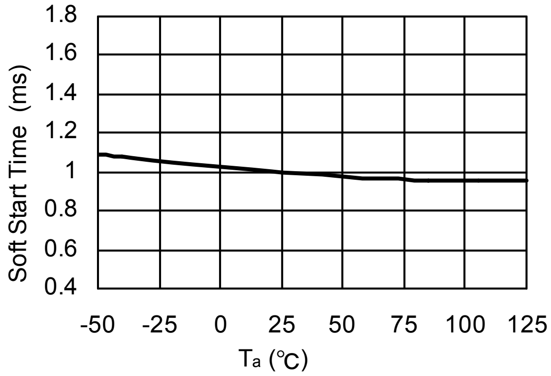
8) UVLO released voltage vs. Temperature



9) Soft-start time vs. Temperature

R1245x00xx

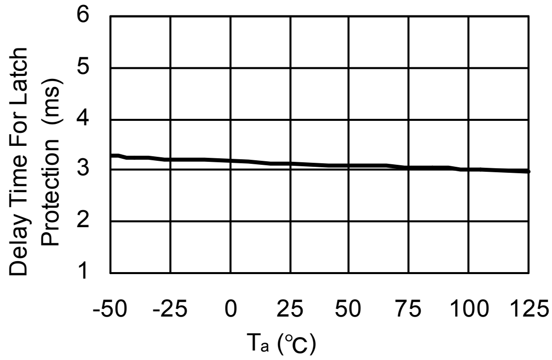
(V_{IN}=12V)



10) Timer latch delay vs. Temperature

R1245x00xx

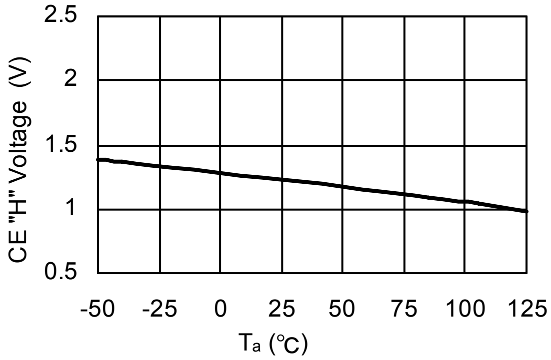
(V_{IN}=6V)



11) CE "H" Input voltage vs. Temperature

R1245x00xx

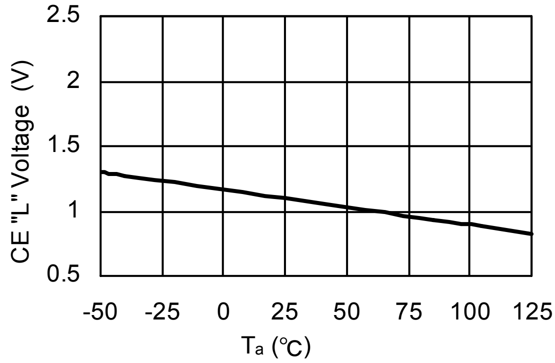
(V_{IN}=12V)



12) CE "L" Input voltage vs. Temperature

R1245x00xx

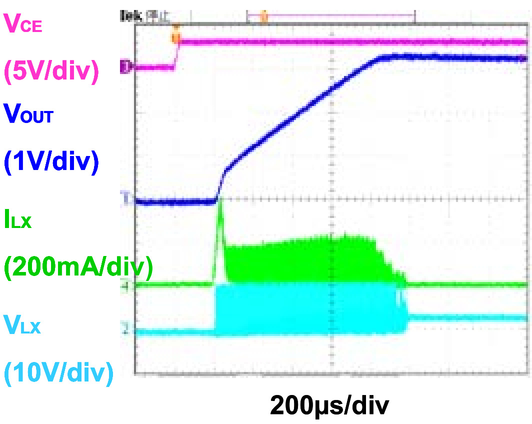
(V_{IN}=12V)



13) Soft-start waveform

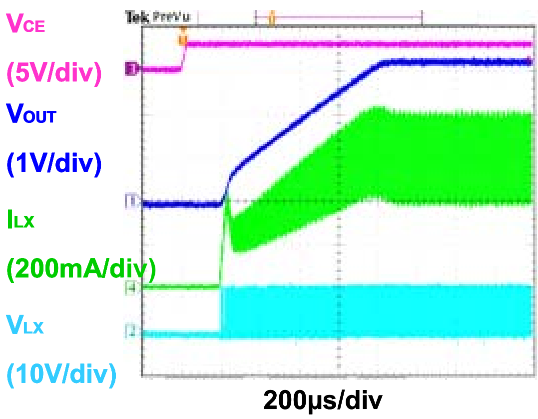
R1245x00xA/R1245x00xB

V_{OUT}=3.3V , V_{IN}=12V , I_{OUT}=0mA , Ta=25°C



R1245x00xA/R1245x00xB

V_{OUT}=3.3V , V_{IN}=12V , I_{OUT}=600mA , Ta=25°C

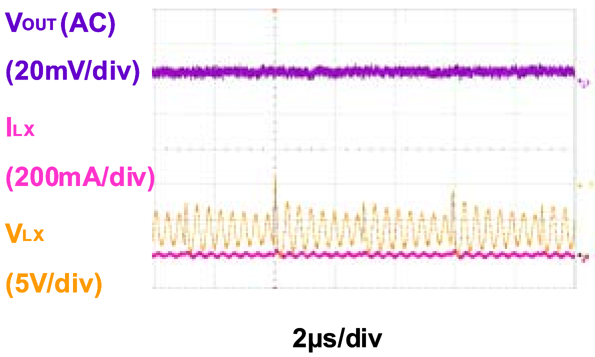


RICOH

14) Switching operation waveform

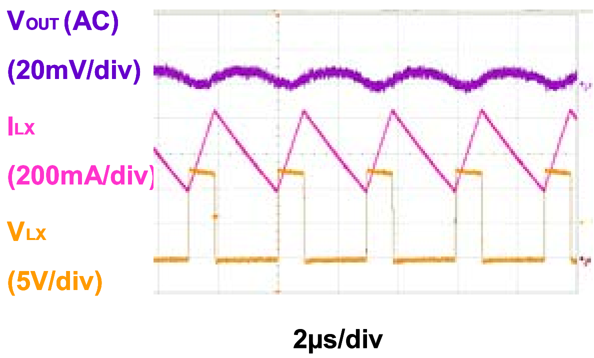
R1245x00xA/R1245x00xB

V_{OUT}=3.3V , V_{IN}=12V , I_{OUT}=0mA , Ta=25°C



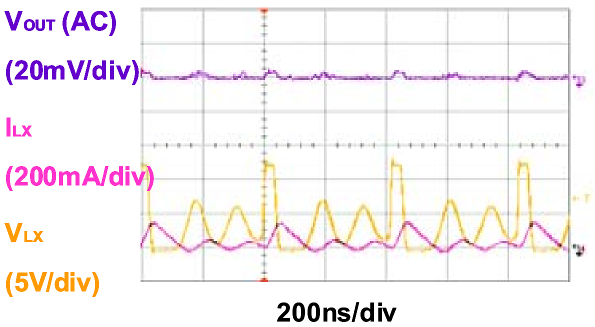
R1245x00xA/R1245x00xB

V_{OUT}=3.3V , V_{IN}=12V , I_{OUT}=600mA , Ta=25°C



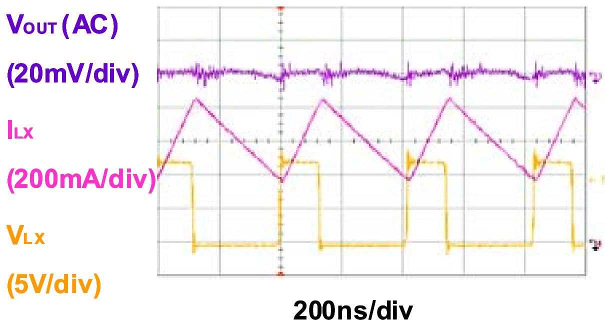
R1245x00xG/R1245x00xH

VOUT=3.3V , VIN=12V , IOUT=20mA , Ta=25°C



R1245x00xG/R1245x00xH

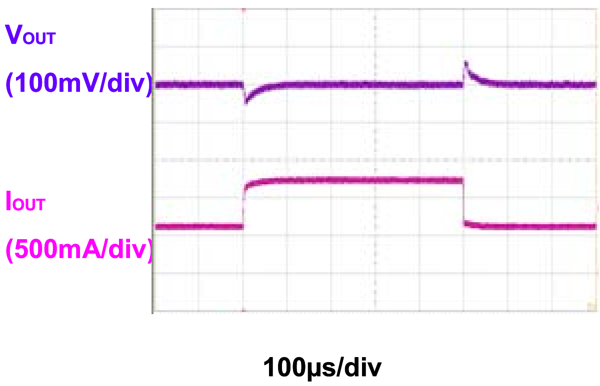
VOUT=3.3V , VIN=12V , IOUT=600mA , Ta=25°C



15) Loaf transient response waveform

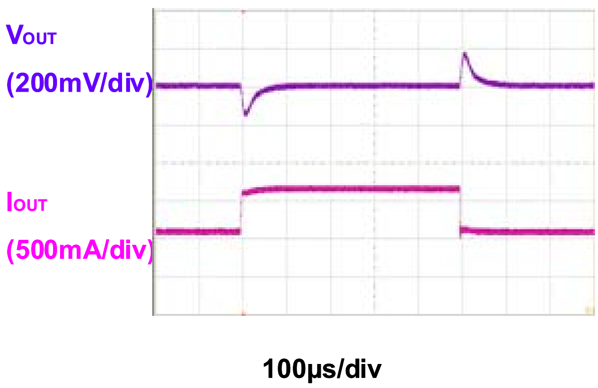
R1245x00xA/R1245x00xB

V_{OUT}=0.8V , V_{IN}=12V , I_{OUT}=600⇔1200mA , Ta=25°C



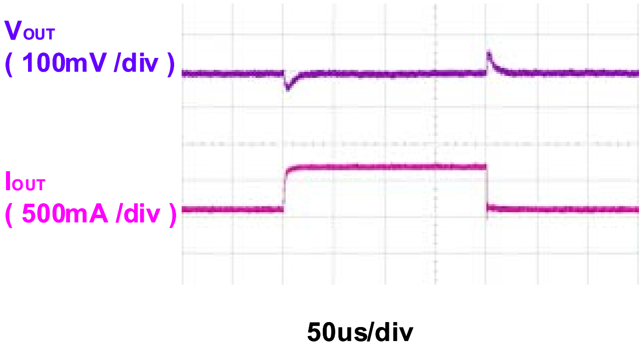
R1245x00XA/R1245x00xB

V_{OUT}=3.3V , V_{IN}=12V , I_{OUT}=600⇔1200mA , Ta=25°C



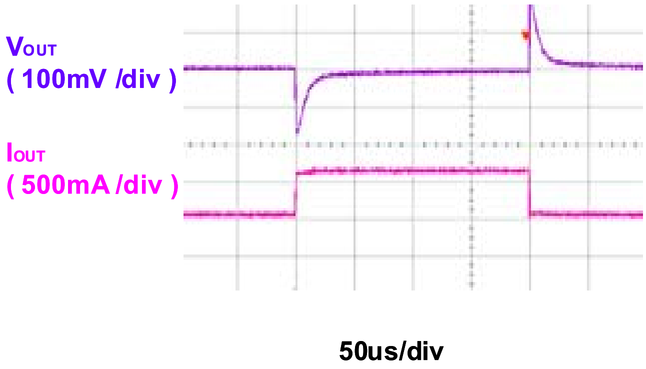
R1245x00xG/R1245x00xH

V_{OUT}=1.5V , V_{IN}=4.5V , I_{OUT}=600⇔1200mA , Ta=25°C



R1245x00xG/R1245x00xH

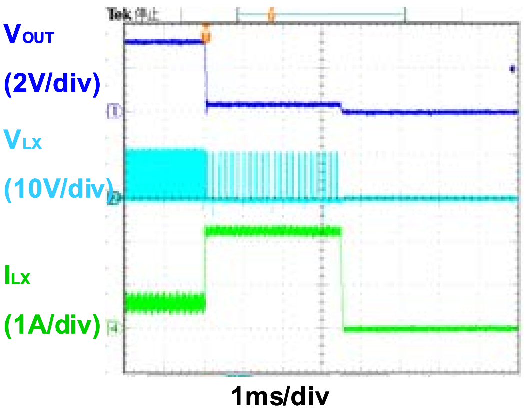
V_{OUT}=3.3V , V_{IN}=12V , I_{OUT}=600⇔1200mA , Ta=25°C



16) Limit latch operation waveform

R1245x00xA

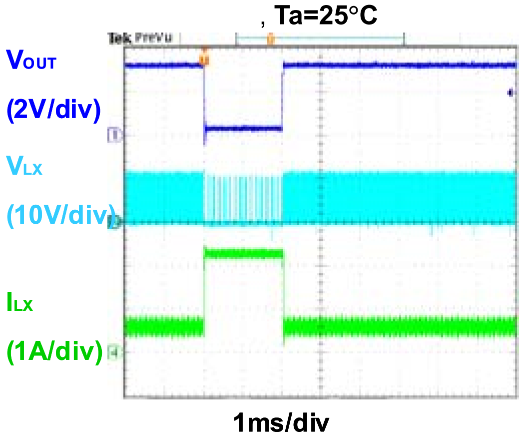
V_{OUT}=3.3V , V_{IN}=12V , R_{OUT}=5.5Ω→0.05Ω, Ta=25°C



17) Released waveform from limit latch

R1245x00xA

V_{OUT}=3.3V , V_{IN}=12V , R_{OUT}=5.5Ω→0.05Ω→5.5Ω , Ta=25°C

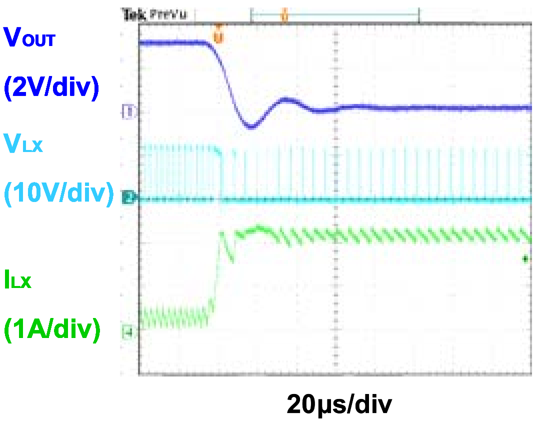


18) Fold back operation waveform

R1245x00xB

V_{OUT}=3.3V , V_{IN}=12V , R_{OUT}=5.5Ω→0.05Ω

Ta=25°C

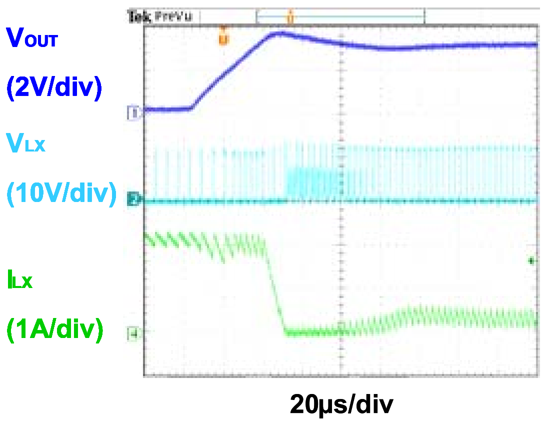


19) Released waveform from fold back

R1245x00xB

V_{OUT}=3.3V , V_{IN}=12V , R_{OUT}=5.5Ω→0.05Ω→5.5Ω

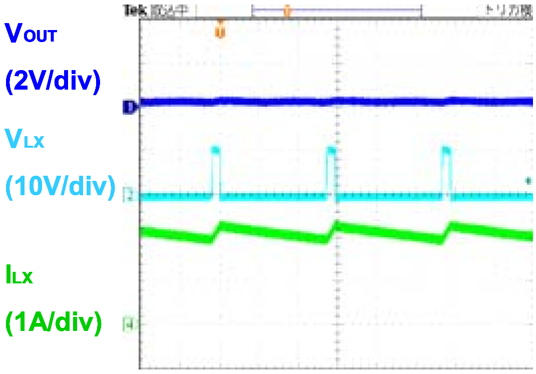
Ta=25°C



20) Switching waveform at fold back operation

R1245x00xB

V_{OUT}=3.3V , V_{IN}=12V , R_{OUT}=0.05Ω, Ta=25°C

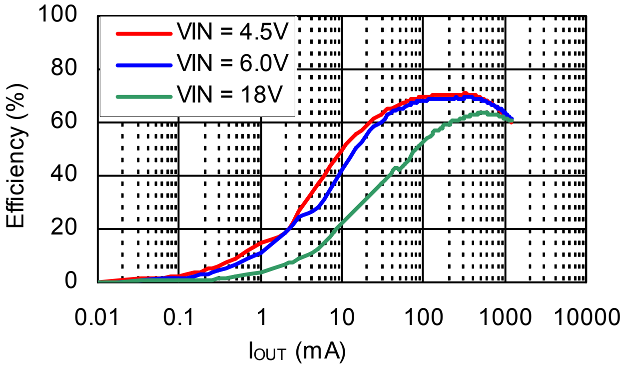


2μs/div

21) Output current vs. Efficiency (Version A/B)

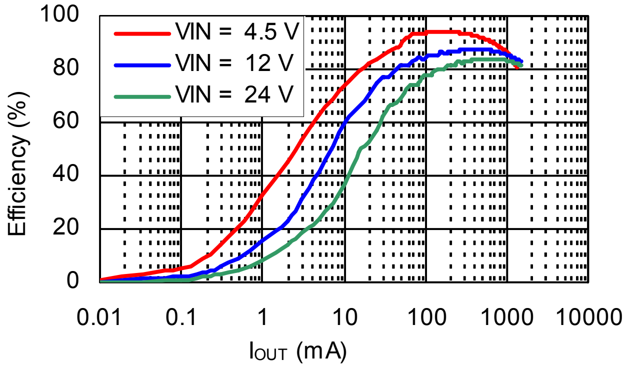
R1245x00xA/R1245x00xB
V_{OUT}=0.8V

(Ta=25℃)



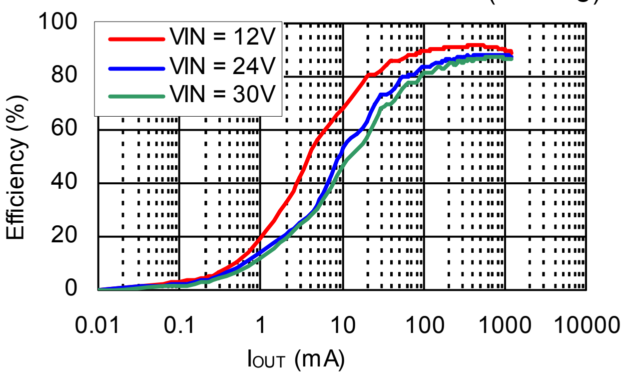
R1245x00xA/R1245x00xB
V_{OUT}=3.3V

(Ta=25℃)



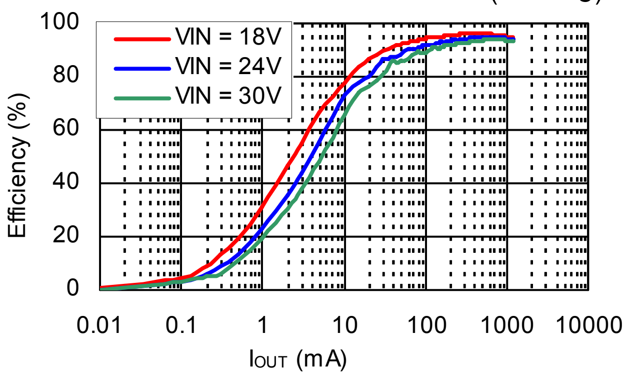
R1245x00xA/R1245x00xB
V_{OUT}=5.0V

(Ta=25℃)

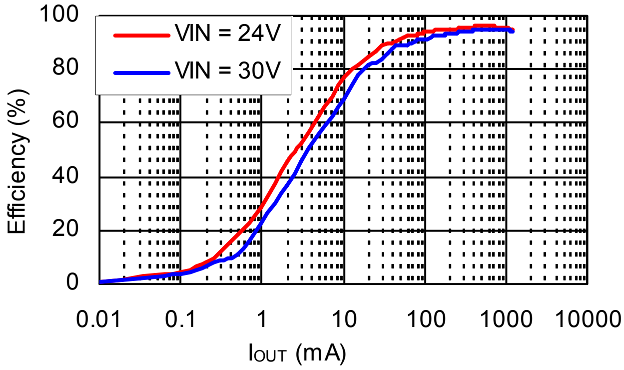


R1245x00xA/R1245x00xB
V_{OUT}=12V

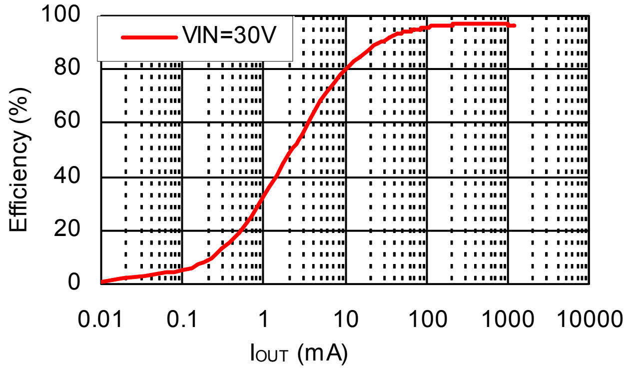
(Ta=25℃)



R1245x00xA/R1245x00xB
V_{OUT}=15V
(Ta=25°C)

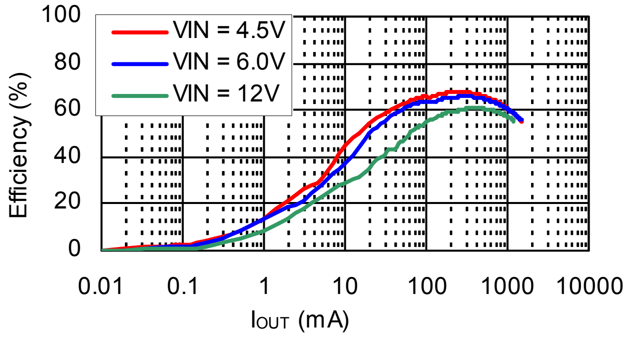


R1245x00xA/R1245x00xB
V_{OUT}=24V
(Ta=25°C)

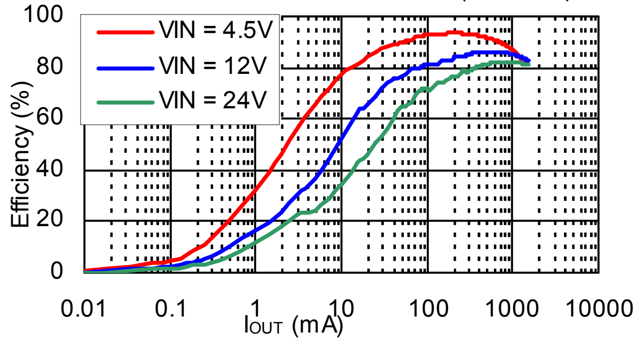


22) Output Current vs. Efficiency (Version C/D)

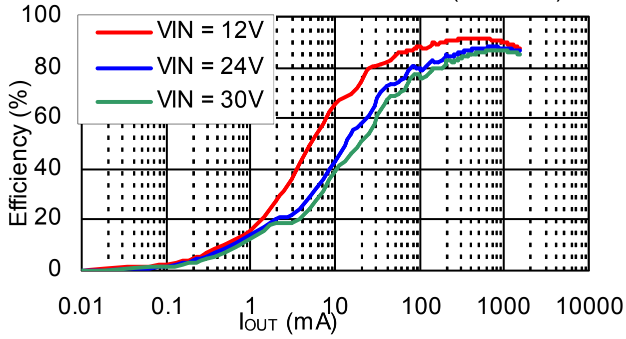
R1245x00xC/R1245x00xD
V_{OUT}=0.8V
(Ta=25°C)



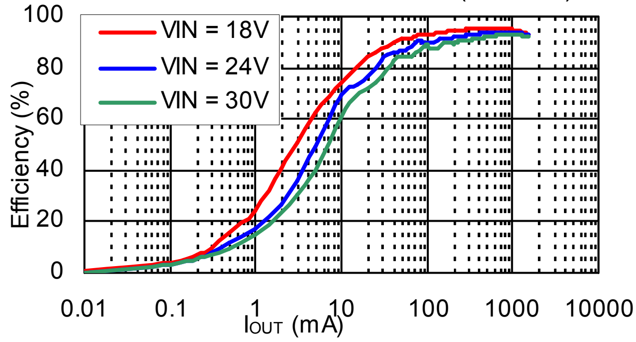
R1245x00xC/R1245x00xD
V_{OUT}=3.3V
(Ta=25°C)



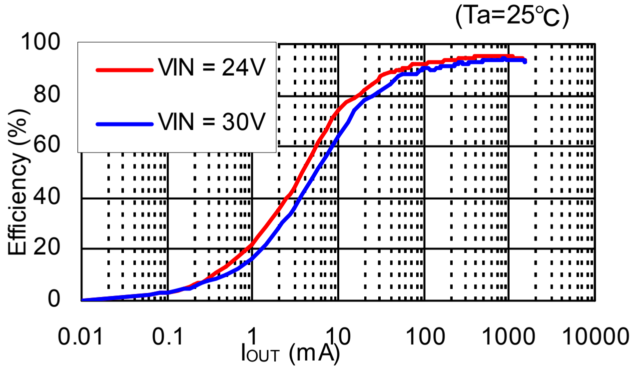
R1245x00xC/R1245x00xD
V_{OUT}=5.0V
(Ta=25°C)



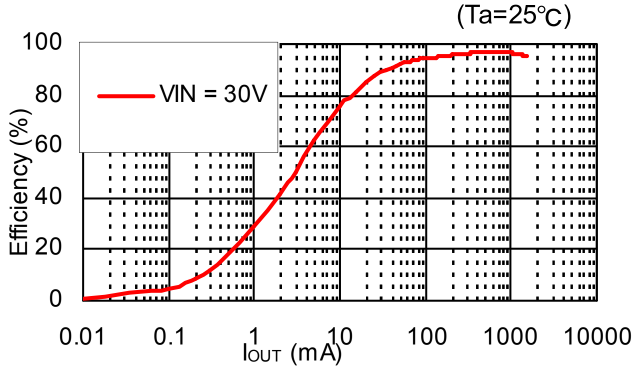
R1245x00xC/R1245x00xD
V_{OUT}=12V
(Ta=25°C)



R1245x00xC/R1245x00xD
V_{OUT}=15V

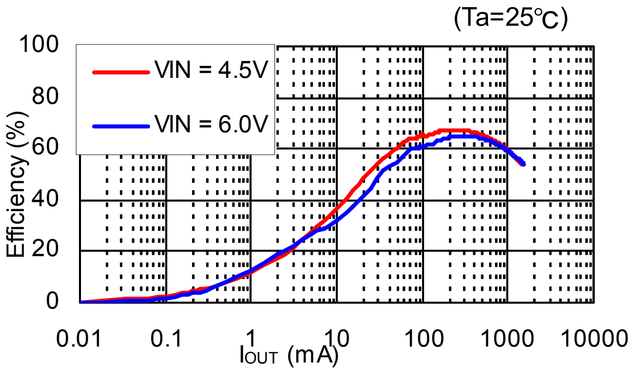


R1245x00xC/R1245x00xD
V_{OUT}=24V

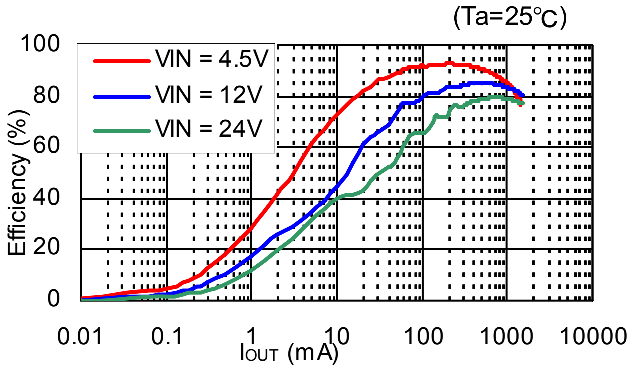


23) Output current vs. Efficiency (Version E/F)

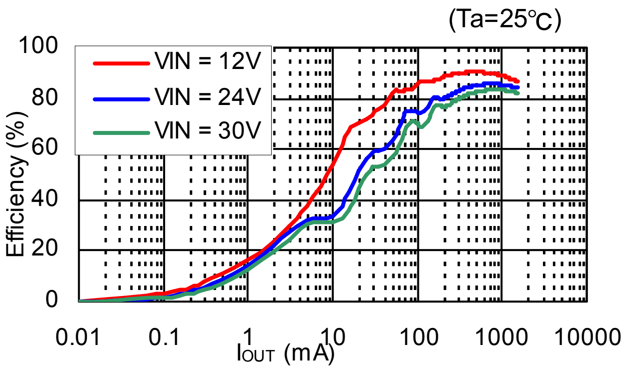
R1245x00xE/R1245x00xF
V_{OUT}=0.8V



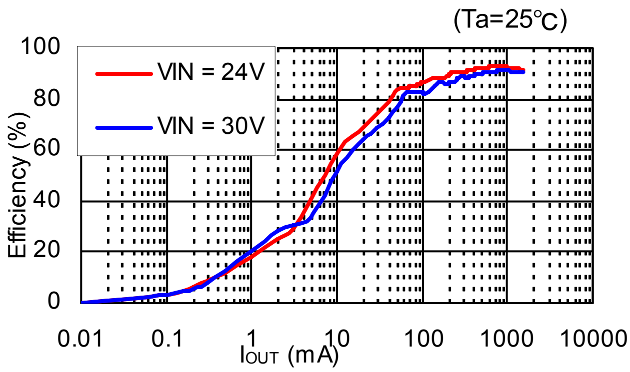
R1245x00xE/R1245x00xF
V_{OUT}=3.3V



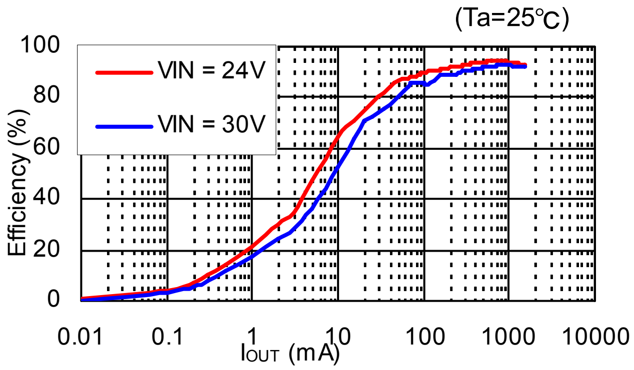
R1245x00xE/R1245x00xF
V_{OUT}=5.0V



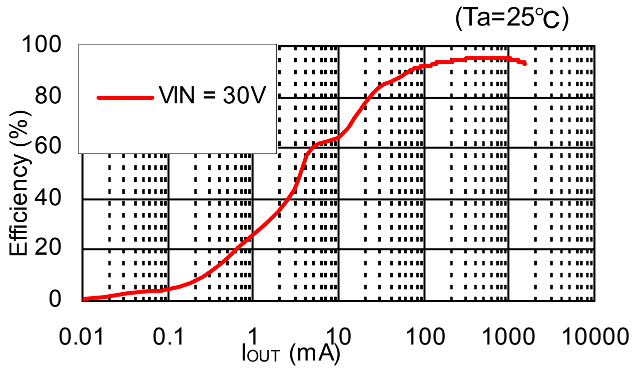
R1245x00xE/R1245x00xF
V_{OUT}=12V



R1245x00xE/R1245x00xF
V_{OUT}=15V

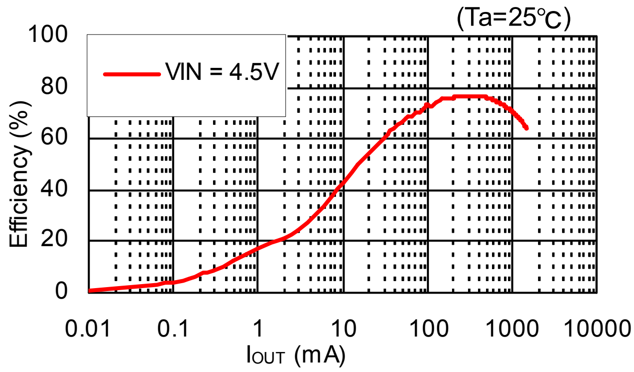


R1245x00xE/R1245x00xF
V_{OUT}=24V

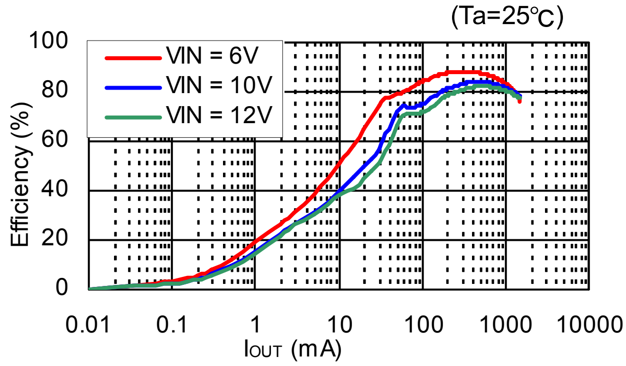


24) Output current vs. Efficiency (Version G/H)

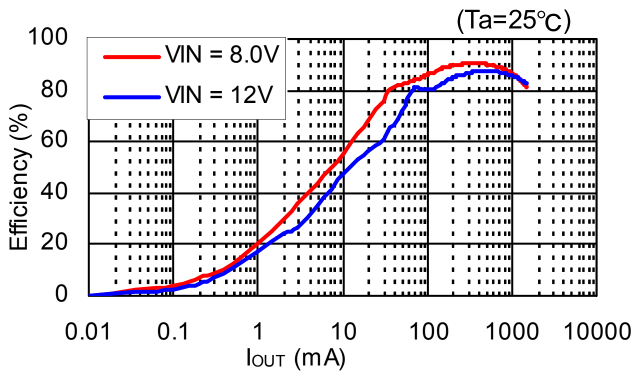
R1245x00xG/R1245x00xH
V_{OUT}=1.5V



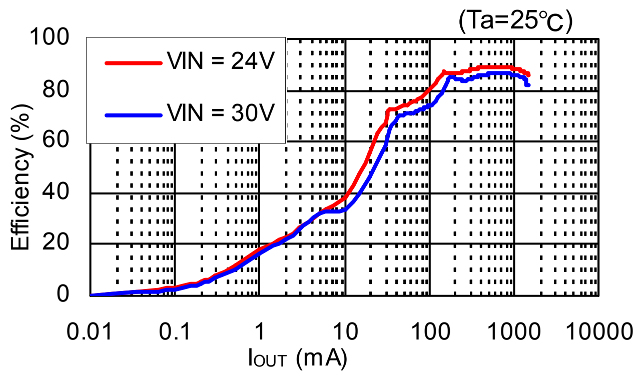
R1245x00xG/R1245x00xH
V_{OUT}=3.3V



R1245x00xG/R1245x00xH
V_{OUT}=5.0V

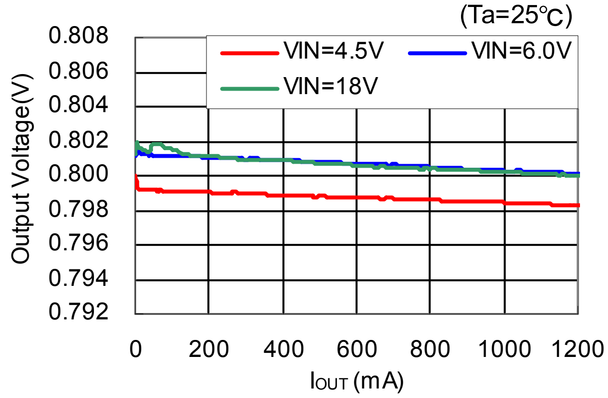


R1245x00xG/R1245x00xH
V_{OUT}=12V

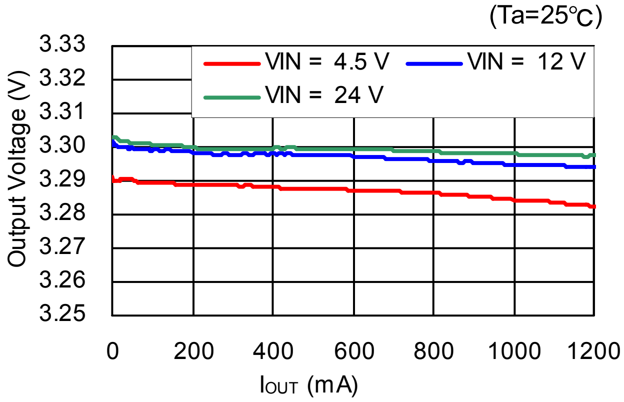


25) Output current vs Output voltage (Version A/B)

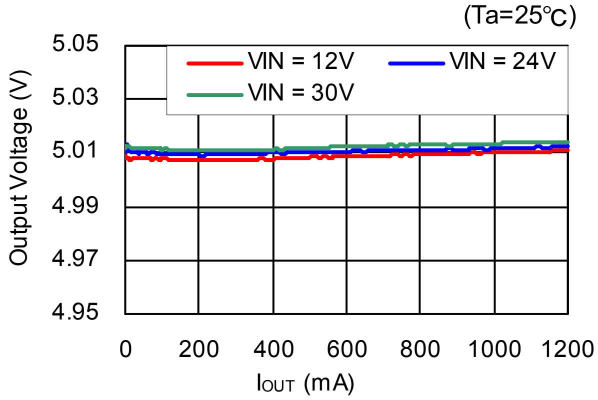
R1245x00xA/R1245x00xB
V_{OUT}=0.8V



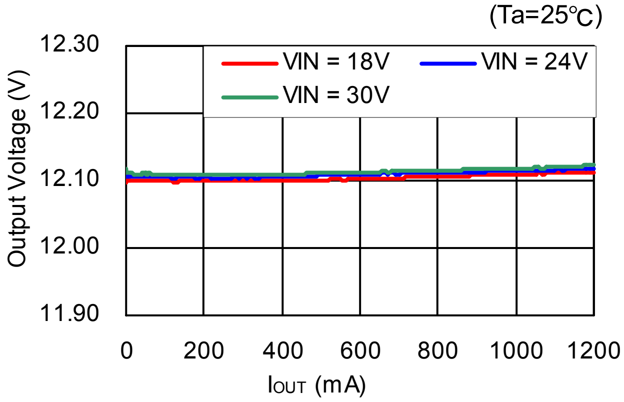
R1245x00xA/R1245x00xB
V_{OUT}=3.3V



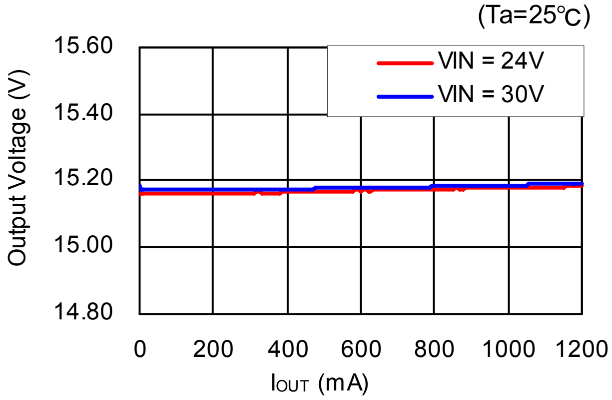
R1245x00xA/R1245x00xB
V_{OUT}=5.0V



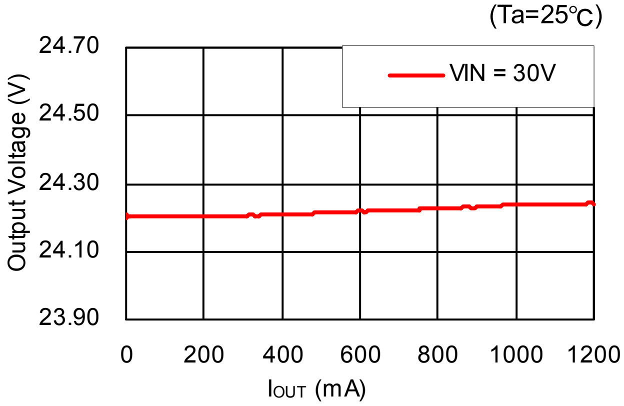
R1245x00xA/R1245x00xB
V_{OUT}=12V



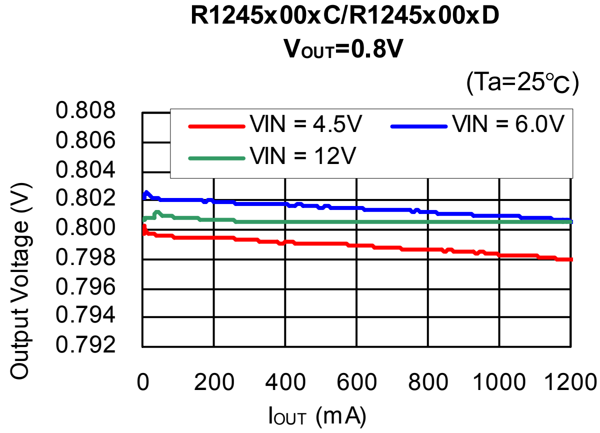
R1245x00xA/R1245x00xB
V_{OUT}=15V

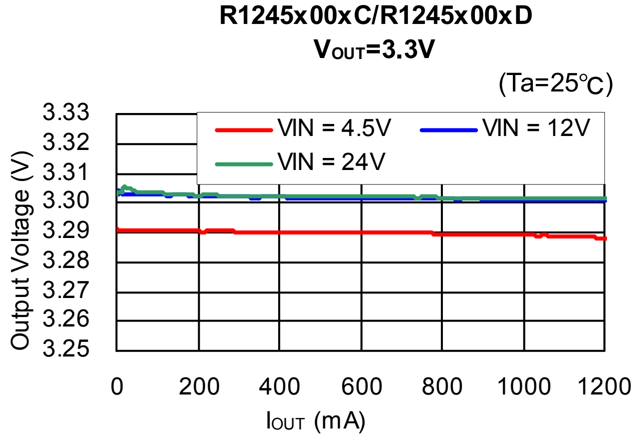


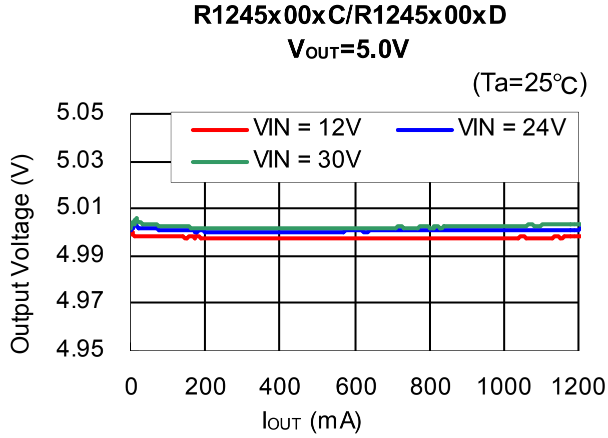
R1245x00xA/R1245x00xB
V_{OUT}=24V

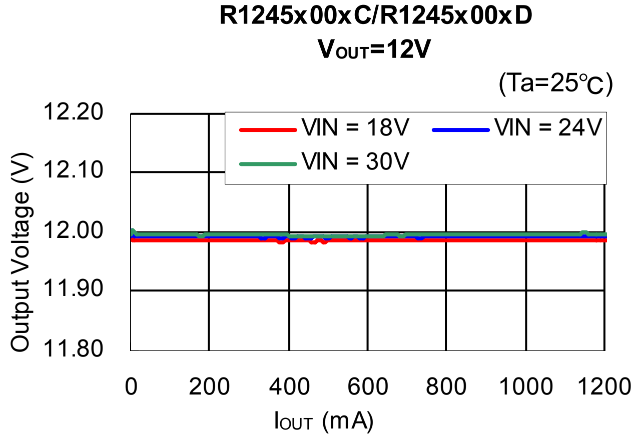


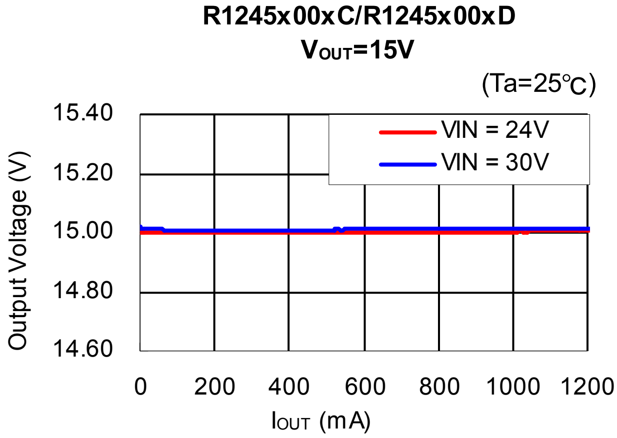
26) Output current vs. Output voltage (Version C/D)

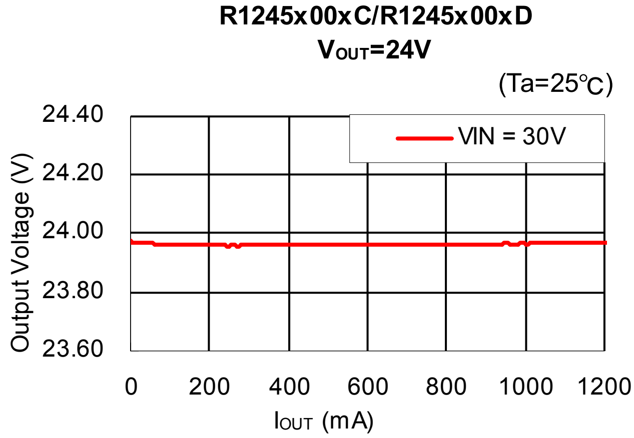




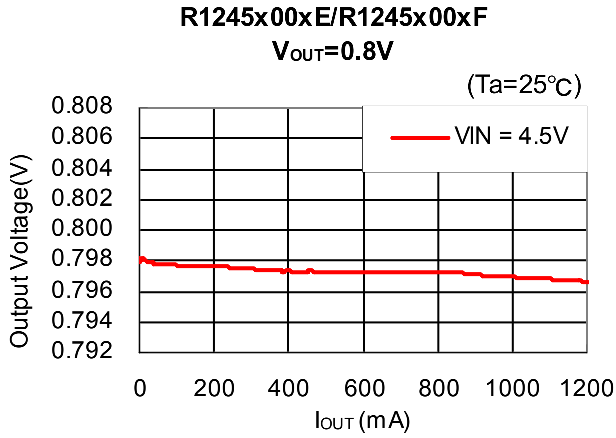


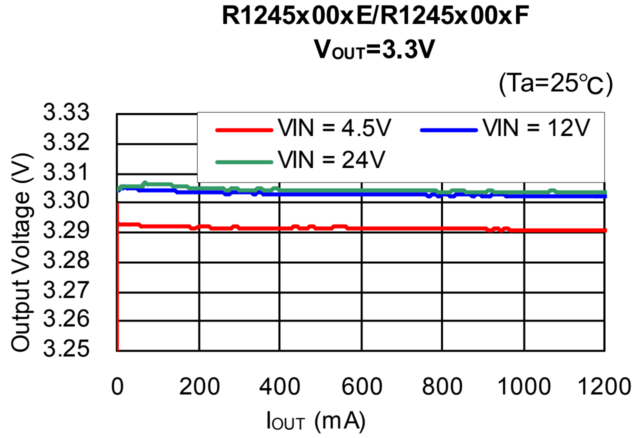


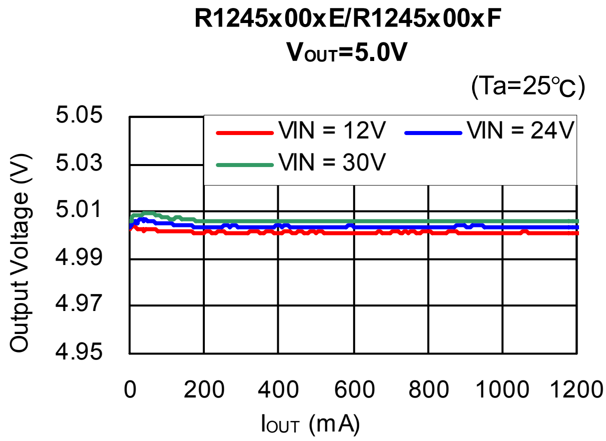


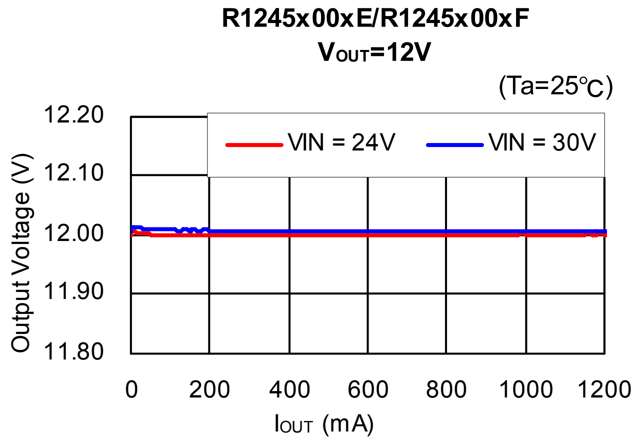


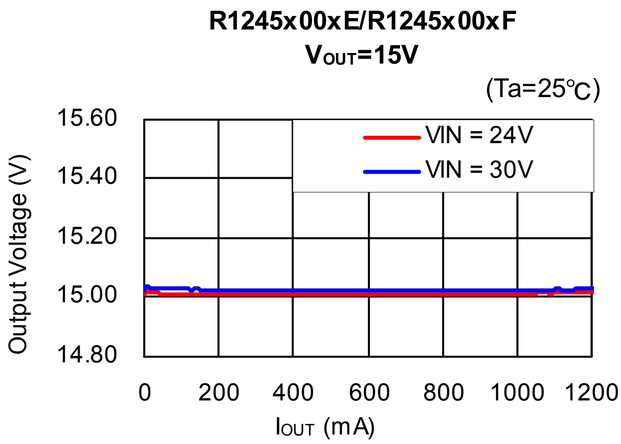
27) Output current vs. Output voltage (Version E/F)

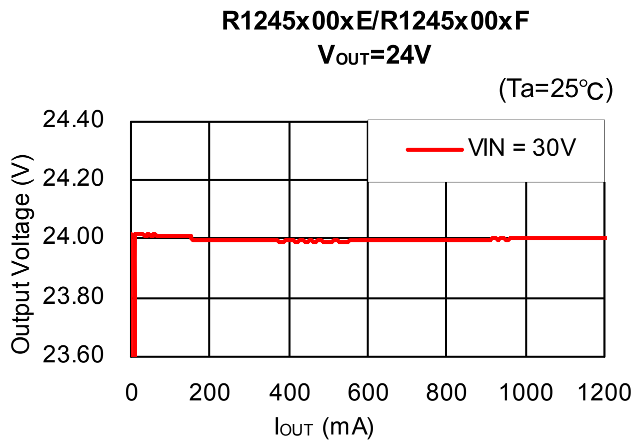








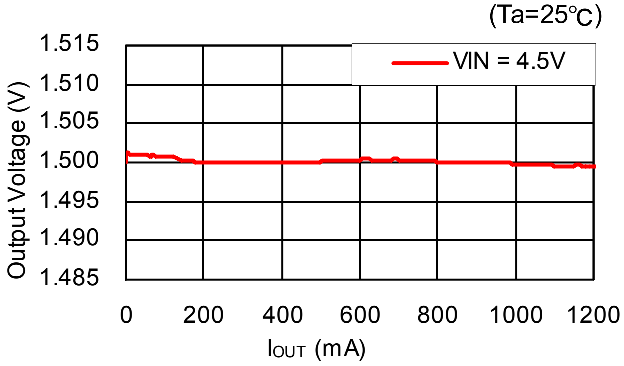




28) Output current vs. Output voltage (Version G/H)

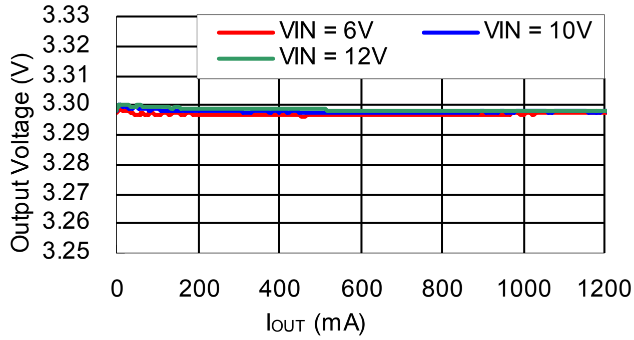
R1245x00xG/R1245x00xH
V_{OUT}=1.5V

(Ta=25°C)



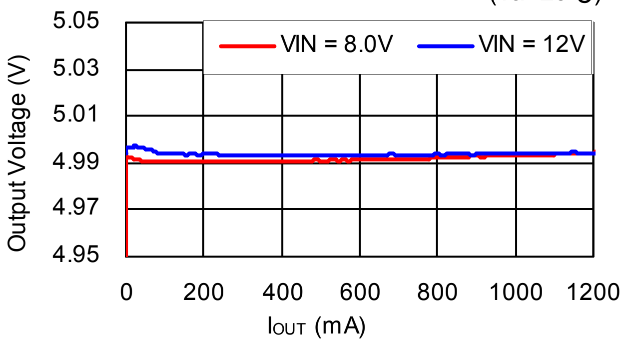
R1245x00xG/R1245x00xH
V_{OUT}=3.3V

(Ta=25°C)



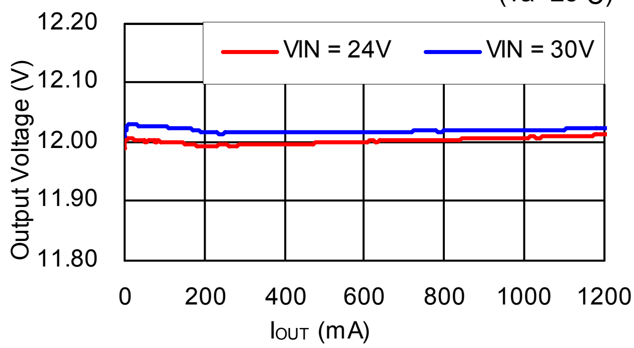
R1245x00xG/R1245x00xH
V_{OUT}=5.0V

(Ta=25°C)



R1245x00xG/R1245x00xH
V_{OUT}=12V

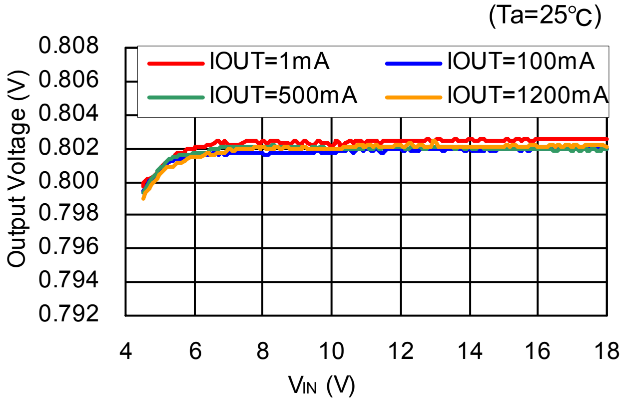
(Ta=25°C)



29) Input voltage vs. Output voltage (Version A/B)

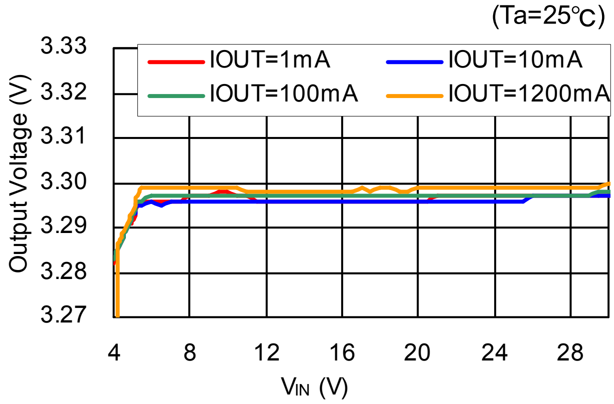
R1245x00xA/R1245x00xB
V_{OUT}=0.8V

(Ta=25°C)

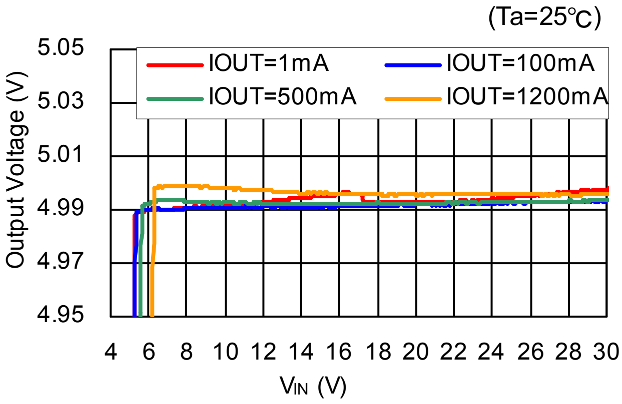


R1245x00xA/R1245x00xB
V_{OUT}=3.3V

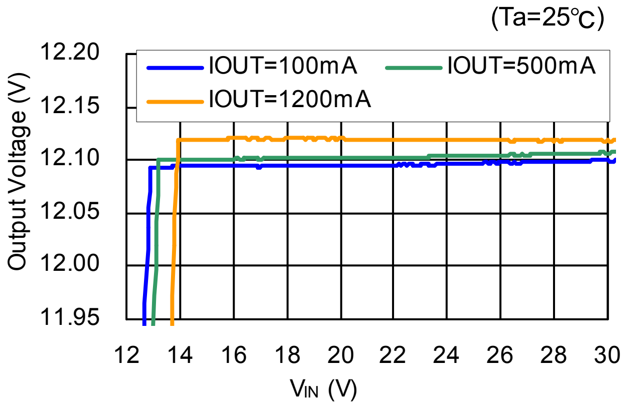
(Ta=25°C)



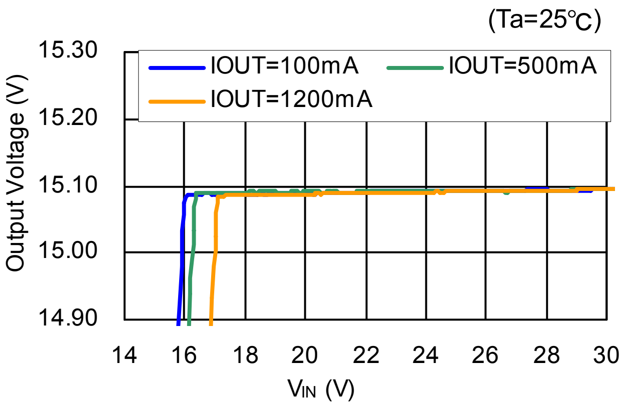
R1245x00xA/R1245x00xB
V_{OUT}=5.0V



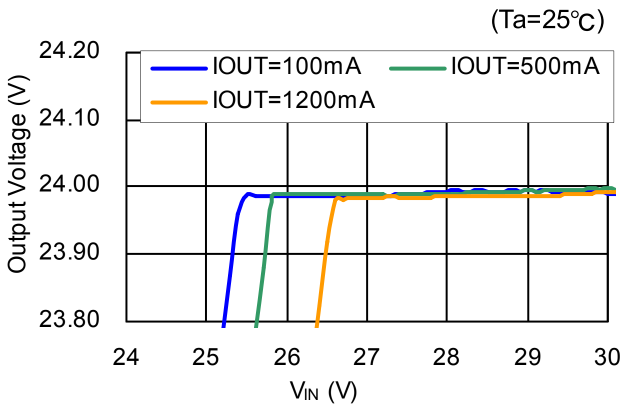
R1245x00xA/R1245x00xB
V_{OUT}=12V



R1245x00xA/R1245x00xB
V_{OUT}=15V

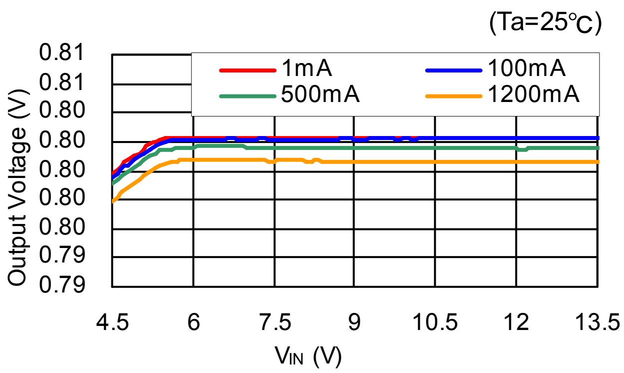


R1245x00xA/R1245x00xB
V_{OUT}=24V

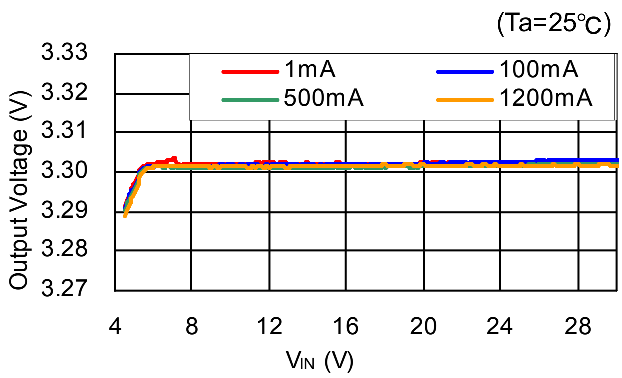


30) Input voltage vs. Output voltage (Version C/D)

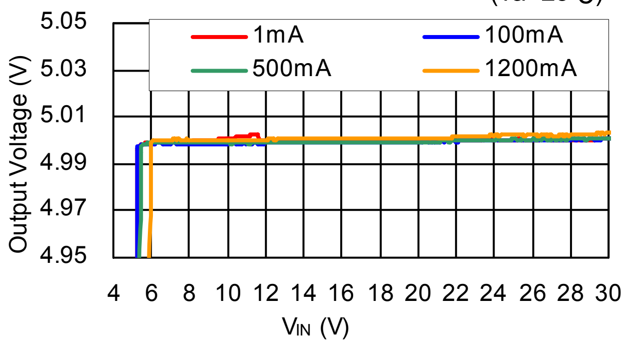
R1245x00xC/R1245x00xD
V_{OUT}=0.8V



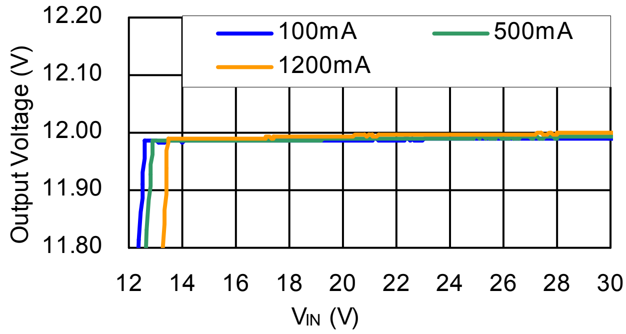
R1245x00xC/R1245x00xD
V_{OUT}=3.3V



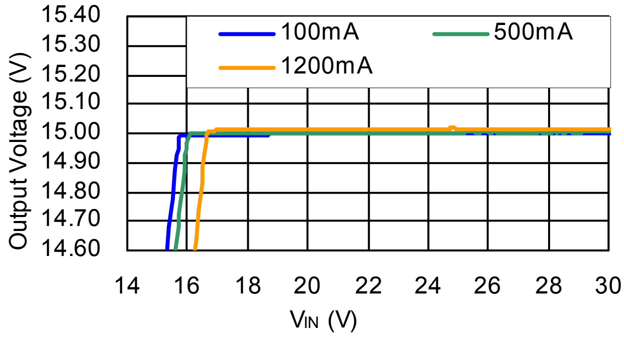
R1245x00xC/R1245x00xD
V_{OUT}=5.0V
(Ta=25°C)



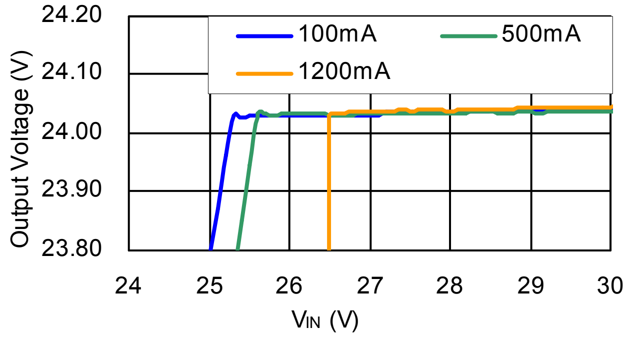
R1245x00xC/R1245x00xD
V_{OUT}=12V
(Ta=25°C)



R1245x00xC/R1245x00xD
V_{OUT}=15V
(Ta=25°C)

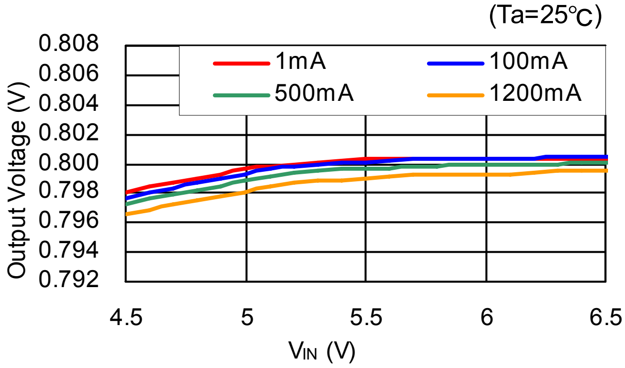


R1245x00xC/R1245x00xD
V_{OUT}=24V
(Ta=25°C)

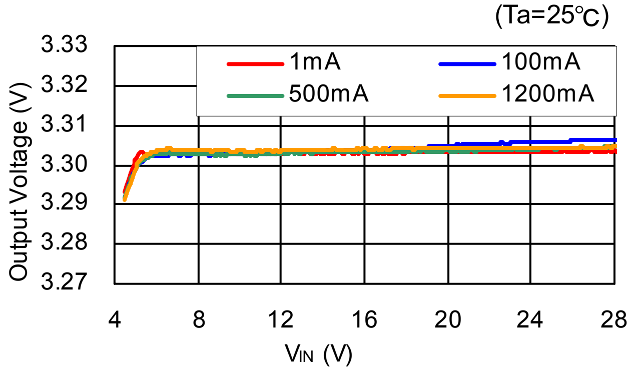


31) Input voltage vs. Output voltage (Version E/F)

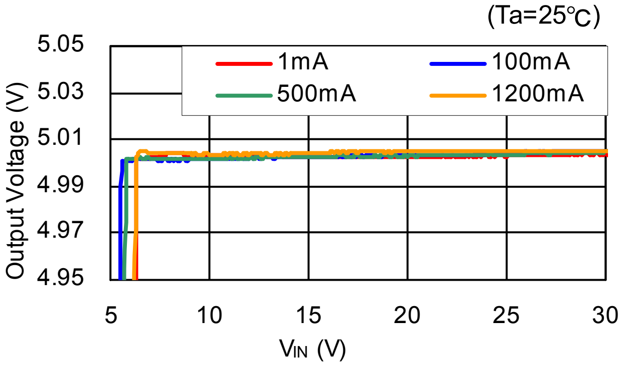
R1245x00xE/R1245x00xF
V_{OUT}=0.8V
(Ta=25°C)



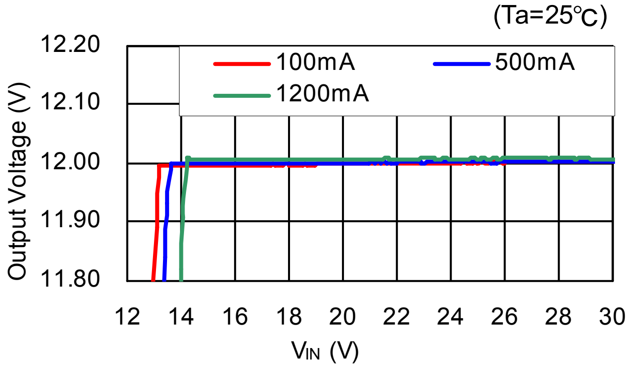
R1245x00xE/R1245x00xF
V_{OUT}=3.3V
(Ta=25°C)



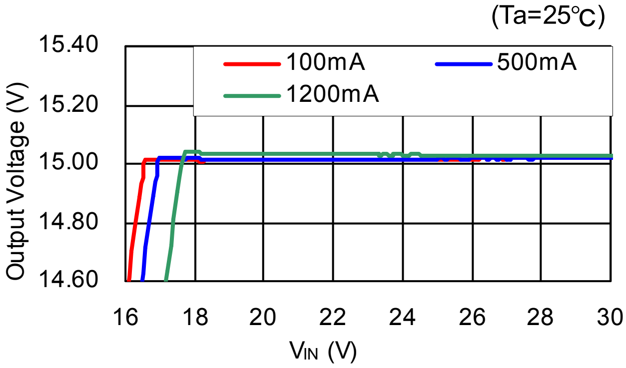
R1245x00xE/R1245x00xF
V_{OUT}=5.0V



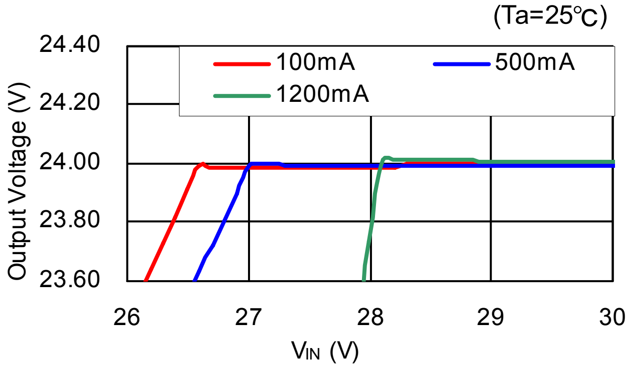
R1245x00xE/R1245x00xF
V_{OUT}=12V



R1245x00xE/R1245x00xF
V_{OUT}=15V

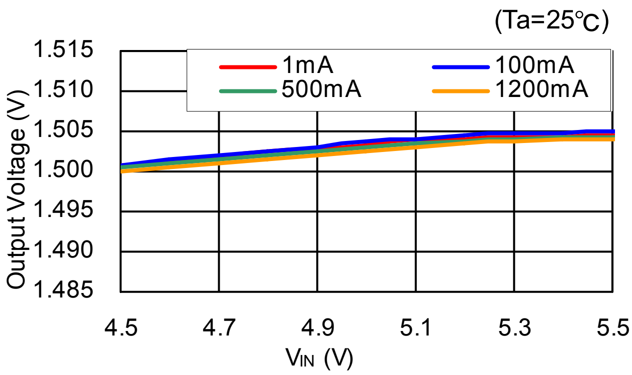


R1245x00xE/R1245x00xF
V_{OUT}=24V

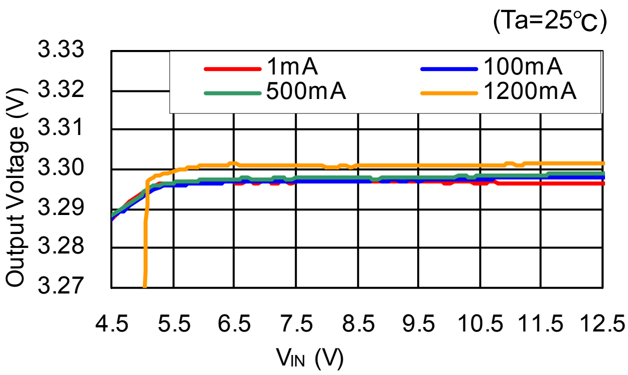


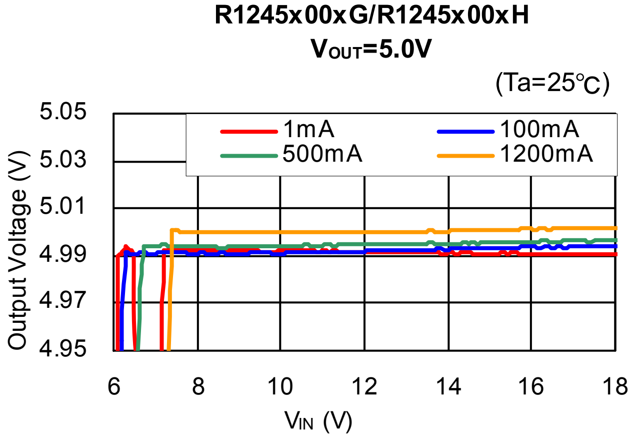
32) Input voltage vs. Output voltage (Version G/H)

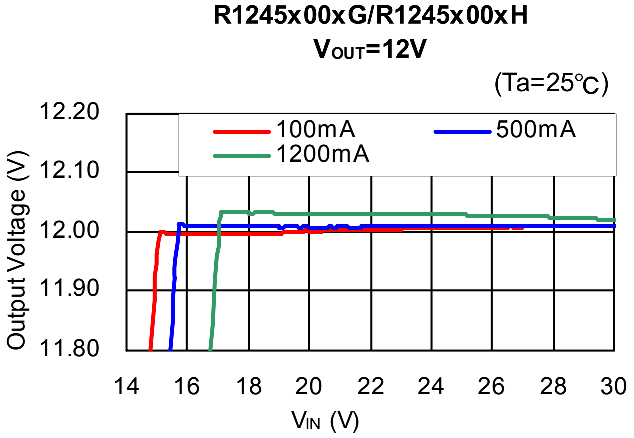
R1245x00xG/R1245x00xH
V_{OUT}=1.5V



R1245x00xG/R1245x00xH
V_{OUT}=3.3V




R1245x00xG/R1245x00xH
V_{OUT}=5.0V
(Ta=25°C)
Output Voltage (V)
5.05
5.03
5.01
4.99
4.97
4.95
1mA
100mA
500mA
1200mA
6
8
10
12
14
16
18
V_{IN} (V)


R1245x00xG/R1245x00xH
V_{OUT}=12V
(Ta=25°C)
Output Voltage (V)
12.20
12.10
12.00
11.90
11.80
100mA
500mA
1200mA
14
16
18
20
22
24
26
28
30
V_{IN} (V)

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RICOH COMPANY., LTD. Electronic Devices Company

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■Ricoh awarded ISO 14001 certification.
The Ricoh Group was awarded ISO 14001 certification, which is an international standard for environmental management systems, at both its domestic and overseas production facilities. Our current aim is to obtain ISO 14001 certification for all of our business offices.

RoHS Compliant

Ricoh completed the organization of the Lead-free production for all of our products. After Apr. 1, 2006, we will ship out the lead free products only. Thus, all products that will be shipped from now on comply with RoHS Directive.

http://www.ricoh.com/LSI/

RICOH COMPANY, LTD.
Electronic Devices Company
● Higashi-Shinagawa Office (International Sales)
3-32-3, Higashi-Shinagawa, Shinagawa-ku, Tokyo 140-8655, Japan
Phone: +81-3-5479-2857 Fax: +81-3-5479-0502

RICOH EUROPE (NETHERLANDS) B.V.
● Semiconductor Support Centre
Prof. W.H.Keesomlaan 1, 1183 DL Amstelveen, The Netherlands
P.O.Box 114, 1180 AC Amstelveen
Phone: +31-20-5474-309 Fax: +31-20-5474-791

RICOH ELECTRONIC DEVICES KOREA Co., Ltd.
11 floor, Haesung 1 building, 942, Daechidong, Gangnamgu, Seoul, Korea
Phone: +82-2-2135-5700 Fax: +82-2-2135-5705

RICOH ELECTRONIC DEVICES SHANGHAI Co., Ltd.
Room403, No.2 Building, 690#Bi Bo Road, Pu Dong New district, Shanghai 201203, People's Republic of China
Phone: +86-21-5027-3200 Fax: +86-21-5027-3299

RICOH COMPANY, LTD.
Electronic Devices Company
● Taipei office
Room109, 10F-1, No.51, Hengyang Rd., Taipei City, Taiwan (R.O.C.)
Phone: +886-2-2313-1621/1622 Fax: +886-2-2313-1623